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Geographic Profiling: Contributions to the Investigation of Serial Murders

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GEOGRAPHIC PROFILING: CONTRIBUTIONS TO THE INVESTIGATION OF SERIAL MURDERS

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Beth Nichols ENTITLED Geographic Profiling: Contributions To The Investigation Of Serial Murders BE ACCEPTED IN FULFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF Master of Arts

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ABSTRACT

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Most research studies have focused on profiling serial killers but have not heavily utilized geographic profiling to complete this work. The purpose of this study is to determine whether geographic profiling software programs can assist in serial murder cases. The study will utilize CrimeStat geographical profiling software to look at the significance of disposal or dump sites, the residence of the killer, and the distance between the dumpsite and the serial killer's residence. This research utilizes a mix -methods approach (case studies and GIS analysis) to analyze five solved case studies of male serial murderers to determine whether they live within the search area, utilizing the Circle Hypothesis. This work also examines the extent to which mental health and intelligence may mediate an offender's decision regarding the location of their disposal or dump site. Research findings indicated that the serial killers live and dump their victims within the search area established by the Circle Hypothesis. In general, findings were inconclusive regarding the impact of mental health or IQ on the distance a serial killer would travel to dump a body. Nevertheless, using an inexpensive geographical profiling software can contribute to the future investigation of serial murder.

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I. INTRODUCTION

Serial crimes take place every day in every country, and they include murder, rape, robbery, and burglary; however, the most lethal is serial murder. As of 2008, the current FBI definition of serial murder is: 'the unlawful killing of two or more victims by the same offender in separate events' (FBI, 2008). Turnbull, Hendrix, and Dent (2000) found that in the United States, serial killers are responsible for approximately, 800 deaths every year. Woodworth and Porter (1999) estimate that there are at least thirty-five active serial killers in the United States. Hickey (2014) stated that there had been 126 serial murderers identified between 2011 and 2013. More recently, Gurian (2017) found that since 1990, there have been 660 suspected serial murderers.

Nevertheless, these totals seem to differ considerably from one another. Those in the field have debated the actual number of serial killers because the totals have not factored in variables such as those victims who are not counted as serial killer victims, missing persons or prostitutes, or those who appear to have died from natural causes such as a heart attack. If these people are not known as victims, then it is impossible to have an accurate number of victims and a serial killer could be unknown for years. Hickey's (2014) research asserted that the number of missing persons range between 30,000 to 40,000, which means we have at least 30,000 possible serial killer victims in the United States. Gurian (2017) proposed that the total number of serial murderers is also uncertain because there is not a clear definition of serial murder. In the 1980s, the FBI defined serial murder consisting of at least three separate murders over a long time in three different locations (Reid, 2017). However, by 2008, that definition lowered to at least two murders. Therefore, if the definition is not clear, it is impossible to know if this is the victim of a serial killer (2017). It also means that there are serial killers who continue to kill without notice to law enforcement.

Historically, law enforcement agencies have investigated cases by using different techniques. They would typically gather evidence at the crime scene, as well as interview witnesses. By the 20th century, law enforcement began seeking assistance from professionals in various fields such as psychiatry, psychology, and sociology. In the 1950s, law enforcement turned to psychiatrists to help them explain the motivations and actions of serial killers (Douglas, Ressler, Burgess, & Hartman, 1986). Psychiatrist James A. Brussel was consulted to assist with the capture of the Mad Bomber George Metesky in 1957. This was considered one of the first psychological profiles utilized by law enforcement. However, psychiatry was not the only field interested in crime and criminal profiling. Mier (2018) found that in time, sociologists felt the need to study crime as well and by the 1960s collective academic interest in the study of crime led to the development of the field of criminology.

Today, criminologists like Jack Levin credit these types of crimes, a series of murders, to the availability of lethal weapons (Ramsland, 2005). Forensic psychologists also began to look at what precipitates' violence evident in violent crimes (Ramsland, 2013). Criminal Profiling has been used by law enforcement in various areas to help identify the type of person who has committed the crime in areas such as hostage situations, rape, and arson (Douglas, Ressler, Burgess, & Hartman, 1986). Douglas asserts that it has been beneficial in serial homicides by looking at the victims for information into the character of the serial killer (1986). Two types are used most of the time; psychological profiling and criminal profiling (1986). Psychiatrist James Brussel used psychological profiling when he helped look for the Mad Bomber (1986). Criminal profiling focused more on a person's thought process. This includes the crime scene, the victim, and forensic information (1986).

In the 1970s, FBI investigative profilers at the Behavioral Science Unit were formed and they began to construct criminal profiles to increase the apprehension of criminals. By interviewing the offenders and compiling case reports, the concept of a serial killer was formed (Reid, 2017). In 2014, The FBI performed an extensive study on 92 serial killers. The study focused on various areas such as motivation, victimology, and body dumpsites for a more in-depth understanding of serial killers (Morton, Tillman, & Gaines, 2014). Reid (2017) discovered that profilers found that many crimes take place close to a serial offender's residence or home base.

By the 1990s, the newest idea for law enforcement was the use of the map in connection with serial crimes. In 1996, the National Institute of Justice wanted to create a tool using maps and geographical information systems, so Ned Levine (2006) developed CrimeStat. While working on his dissertation, Dr. Rossmo created Rigel and Criminal Geographic Targeting. Dr. David Canter created Dragnet, and Dr. Maurice Godwin developed Predator. Some law enforcement agencies finally added a geographic profiling software, a computer program using maps to find the home base or residence of a serial offender, as an effective tool in their investigations (Rossmo, 2000). However, law enforcement agencies in the United States rarely use these tools to solve serious serial crimes.

Nevertheless, Medeiros stated that geographic profiling is used regularly in the United Kingdom in high profile cases (Miller, 2014). The Centre for Geospatial Intelligence and Investigation in Texas, founded by Rossmo, has worked with the US Border Patrol to identify illegal immigrant patterns coming into the USA as well as helping to locate IEDs in places like Iraq. Rossmo (2000) also believes that geographical profiling can be useful in finding terrorist patterns.

Previous studies have determined that computer software has been an asset in areas such as crimes and epidemiology (Papini & Santosuosso, 2017). The purpose of this study is not only to determine whether geographic profiling assists in serial murder cases, but it will also utilize the computer software to look at the significance of disposal or dump sites, the residence of the killer, and the distance between the dumpsite and the serial killer's residence. These are essential clues because most people stay within their comfort zone. So, if an individual generally stays within a specific area, it is very likely that a serial killer will also stay in his/her comfort zone and commit crimes. Finally, this work will examine the extent to which mental health and intelligence may mediate an offender's decision regarding the location of the dumpsite.

This study will explore five different serial killers through various case studies to determine whether the serial killer lived within a geographical proposed area using an easily accessible computer software program. These five case studies will be collected from data available on the known serial killers through articles and books. The five serial killers must meet the following criteria; commit the crimes between 1960 and present day, live stably at one residence at the time of the crimes, operate alone, and used the same signature. The study also chose to narrow the search to those who lived at one residence, operated alone, and used the same signature to eliminate various issues such as bias.

This study is significant because while it is critical to apprehend a serial offender, serial killers, are often sophisticated individuals that do not fit into one typology. This study intends to investigate geographic profiling as a beneficial tool in the capture of serial killers by showing that they commit their crimes close to their residence or another significant anchor point. It is hoped that these results will also be beneficial to the future study of profiling and ultimately change how investigators solve serial crimes.

II. LITERATURE REVIEW

History of Serial Murder

Contrary to popular belief, Jack the Ripper was not the first serial killer. Some of the first known serial murderers are found during ancient times such as Tiberius and Caligula in A.D 14. Kerrigan (2008) states that after returning to Rome from Capri, Tiberius was known to be a cruel man. He held executions daily of people he felt needed to die and watched from afar. He had two of his adopted sons killed. However, while he was on Capri, Tiberius surrounded himself and his other adopted son, Caligula, with every perversion known by man, such as having children trained to lick and bite his body as he swam by, to having daily orgies. It is no wonder that his young child, Caligula, showed signs of madness early on, primarily being raised in such a peculiar environment (2008). Kerrigan also states that Caligula in A.D. 47 was a monster as well. It is said that he had plotted to and had Tiberius killed. He began his reign calming his people; however, after a bout of an illness, it appears that Caligula went mad and showed signs of sadism. He gave orders for executions for frivolous things and loved seeing the torture and death of his prisoners, especially by a gang of animals (2008).

Some of the next known serial killers were Vlad the Impaler and Gilles de Rais during the 1400s. Burgan (2011) found that between 1456 and 1462, Vlad III Dracula or better known as Vlad the Impaler, impaled his enemies on stakes in the ground and left them there to die. He even ordered the deaths of his people over minor crimes. Schechter (2012) discovered that Gilles de Rais, who was a nobleman who killed over one hundred boys in the 1440s (2012). He was known by many names such as the devil and vampire (Reid, 2017). Miller (2014) asserted that he found more pleasure in torture and killing than sex with his victims.

Between the 15th and 16th centuries, society was focused on religion and the conquering of it, so paranoia was rampant. Therefore, the killings that were mutilated were blamed more on werewolves because the belief was that no human could be responsible for this kind of torture (Miller, 2014). The other killings were blamed on witches, and during this time, many people were put on trial and executed (Vronsky, 2018). Either the werewolf or the witch, these killers made a pact with the devil (2018). In 1589, Peter Stubbe was considered a man who made a pact with the devil; however, the reality was that he raped, killed, mutilated, and cannibalized eighteen victims (2018). Jacques Roulet murdered and cannibalized multiple children and adults in 1598 (2018).

Between the middle of the 17th to the middle of the 19th century, the countries were transforming after numerous wars and the beginning of the industrialization age (Vronsky, 2018). Nevertheless, serial killers were still around; however, the focus was more on robbing people or poisoning them. In the 1660s, Catalina De Los Rios Y Lisperguer became famous for torturing her people and murdering her paramours, as well as family members. Delphine LaLaurie killed her slaves in the early 1800s in Louisiana. Moreover, Martin Dumollard had at least killed three women in France (2018). Lastly, in 1808, Andreas Bichel killed multiple servant girls and had a clothing fetish (2018), and in 1850, Francois Bertrand killed fifteen people and gave them smiley faces (2018).

Hickey (2014) stated that there had been at least 133 serial murderers dating back to the middle of the 1800s. The most well-known serial killer is Jack the Ripper. Perhaps he is so famous because he was never caught or perhaps it was because he liked playing with law enforcement during the time of his crimes. Either way, he is known for introducing the concept of serial killing into the lexicon of history. He is also known for the gruesomeness and the

brutality of his killings. Jack the Ripper murdered prostitutes by stabbing, removing their bowels, and either placing the organs around the body or taking them (Miller, 2014).

Selzer discovered that in 1893, one of America's first serial killers, Dr. H.H. Holmes, murdered his friend for life insurance money and then continued to kill twenty-seven people over the next eight years (Selzer, 2017). Dr. H.H. Holmes had many aliases; however, he was born as Herman Webster Mudgett, and he built "the Castle" which had secret stairways and trapdoors. This is where his guests came in but never came out again. He sold the bodies to medical schools, set up torture chambers, and had an acid bath and furnace to dispose of the bodies (2017). Other research by Telfer (2017), uncovered that in 1852, Mary Ann Cotton poisoned her husbands as well as her lovers in Great Britain for money. She even killed her stepchildren and some of her own children. Interestingly, they cannot explain why two of her children survived. Other findings indicated that Belle Gunness who was known as Lady Bluebeard was also known for poisoning who came to her farm, though it could not be proven that she killed her children or both her husbands (Schechter, 2018).

As stated, there were serial killers throughout history; however, it appears that by the 20th century, serial killers became more elusive and the killings harder to identify. Miller (2014) proposed in his research that there were probably less than ten serial killers in the United States until the 1970s. Jenkins (2005) asserted that murders began occurring with more frequency in the 1900s. White (2007) found that in the 1920s, Albert Fish liked killing and had many peculiarities such as sadism, masochism, he liked children the most, and he ate their flesh. White also discovered that in the 1950s, Ed Gein liked digging up his dead bodies (2007). In the 1960s. Albert DeSalvo took crime to a new level when he started killing after a career in burglarizing homes (Miller, 2014). Cheney found that Edmund Kemper began killing in 1964. In 1973 he

eventually turned himself in because after he killed his mother, and his purpose for killing others was gone (Cheney, 1976). Haugen (2011) asserted that the Zodiac Killer, who has yet to be caught, began killing in 1968 but eventually ended his spree in 1974, for some unknown reason.

Gurian (2017) discovered that most serial killers became more active after 1970 and activity dwindled after 2000. During the 1970s, it appears that many serial killers were actively killing in various areas around the United States. In 1972, Ted Bundy started his spree of killing that spanned seven states with the actual number of victims still unknown today (Ramsland, 2013). While Ted Bundy was a charming bachelor, Amirante & Broderick (2011) affirmed that John Wayne Gacy, Serial Killer Clown, was a married businessman who killed 33 young men inside his home and buried most under his home in the 1970s. Lynes and Wilson (2015) stated that in 1974, Dennis Rader, the BTK Killer, was also a working man who was involved in his church, but he led another life of murdering ten people. In 1976, David Berkowitz, the Son of Sam, began shooting people in their cars because he was commanded to do it by his neighbor who sent the message through his dog who was possessed by a demon (Bonn, 2014). Bonn (2014) also stated that Jeffrey Dahmer started luring men home, killing and dismembering his victims two years later; in 1978. Levi-Minzi and Shields (2007) observed that in 1982, Gary Ridgeway the Green River Killer began killing and dumping bodies in forested areas around the county. He continued killing until 1998; however, he was not caught for another four years; in 2001.

Female serial murderers are much more common than was previously assumed. Colloquially, Aileen Wuornos has been dubbed the first female serial killer; however, Telfer (2017) uncovered that Countess Erzsebet Bathory was one of the first female serial killers with exploits dating back to the early 1600s. She had unusual tastes that included torturing young, innocent girls in her torture chamber. She liked bathing in the blood, however, when that stopped working for her,

and she felt she needed money, she progressed to killing well-bred girls who sought tutoring in her finishing school. A witness said at an inquest that Countess Bathory ended up killing at least six hundred girls; however, no one knows the exact count (2017).

Telfer (2017) indicates that in the 1880s, Lizzie Halliday born Eliza Margaret McNally began killing as soon as she was released from an asylum and met her husband. Initially, she killed his son by burning the house down and the barn. Once the law found evidence against her, she ran and was apprehended and sent to an asylum again. After her husband took her back, he disappeared a year later. Neighbors then took it upon themselves to search the farm, and they found three bodies. Interestingly, she was released both times because she was considered cured of insanity.

Issues with the Definition of Serial Murder

Morton and Hilts (2005) state that serial murder is not new, nor it is unique. There is even a debate on the etymology of the term 'serial killer.' While the term serial killer is certainly not old, there is considerable debate as to who originally coined the term. There have been multiple definitions of serial murder which, had common characteristics; however, the number has changed over the years. In 1998, a federal law passed so that criteria could be established when the FBI could assist law enforcement in an investigation. Serial killings were defined as a series of three or more killings that have universal themes (Morton & Hilts, 2005). As of 2008, the current FBI definition of serial murder is: 'the unlawful killing of two or more victims by the same offender in separate events' (FBI, 2008).

The FBI states that former FBI Agent Robert Ressler first used 'serial murder' in the 1970s. However, Sasha Reid (2017) found it in a German newspaper: Serienmörder, which translates as a serial killer. Additionally, also discovered that it was used in 1929 by a Berlin Chief of Police,

Ernst Gennat to describe a person who murdered in a series. The term was used by many others historically. For example, it was found in a book written by Piper in 1957 to explain a person with violent hatred. The term was also seen in a Richard Hughes book in 1950 and used to reference a double murder. Additionally, there is also a John Brophy 1966 book that used serial murder in reference to several murders that established a sequence (2017). Nevertheless, it would not appear for public consumption for another 50 years in the United States (2017). In any case, the term proliferated throughout literature and the media before the FBI coined the term and it became known to the public.

In addition to issues of etymology, there is a debate on what constitutes the minimum number of victims for a case to be considered serial murder. In the 1990s, the FBI considered a serial killer had to have at least three victims over some time in separate locations (Reid, 2017). By 2008, the definition changed to at least two victims over a period of time (FBI, 2008). The definition never specified the sex of the serial offender; however, it did not consider female serial killers. Nevertheless, until recently, serial killers were considered to be male and motivated by sex with a stranger (Reid, 2017). These are just some of the critical factors that need to be considered when finding a proper definition of serial murder.

Due to the cascading effect of the above issues with the definition, the exact number of victims has also hindered law enforcement in labeling the cases as the work of a serial killer. Some studies suggest that the victim numbers are in the thousands, which would mean that there are at least 200 serial killers active at any given time. Jenkins (2005) proposed that the excessive number of serial murderers in the United States was a result of many issues. More recent studies indicate the number is fewer than previously stated. Hickey (2004) believes that there are approximately 30 to 40 serial killers active at any given time; however, Quinet (2007) indicates

that we still do not have an accurate count. For example, Herbert Baumeister of Indiana killed at least 16 victims in 16 years, and most of his victims were first reported missing. Law enforcement hesitated to say that they had a serial killer at large. More intriguing is the fact that 23% of the victims were reported missing in the Green River Case. It took over five years for one victim to be reported missing after she disappeared (2007). However, the missing are not the only victims. According to NCIC, there are currently 6,036 unidentified people in their records (NCIC, 2006). Quinet recommended that in the BJS survey (13,486) it is twice that of the NCIC figure of unidentified people reported. There are also those who are misidentified or listed wrong when, in fact, they are the result of murder (2007). Therefore, a serial killer remains undetected and free to continue to commit murder.

Research by Reid (2017) indicates that female serial killers are not accounted for in the original definition of serial killers because the definition seems to focus on sexual motivations. Therefore, the definition does not account for females that would typically kill for financial gain. Reid findings also indicated that victims of female serial killers are more likely to be children and elderly individuals. Fox, Levin, and Quinet (2005) unearthed that female serial killers are more apt to murder in hospitals because of the opportunity. Moreover, if we do not include female serial killers, then our number of victims are inaccurate (Quinet, 2005).

Nevertheless, it appears that different factors have been overlooked when it comes to defining and categorizing serial murders (2017). Therefore, perhaps researchers should consider Reid's (2017) idea of considering the killer's historical roots to arrive at an accurate definition. Historically an individual who murders over a long period of time was a standard definition, regardless of sex. Reid's new term Compulsive Criminal Homicide (CCH) focuses on serial killers that appear to be compulsive in their thought process (2017) and help indicates a possible

change in the trend of identifying possible serial killers. We have not focused on the real problem; a serial killer in the midst, that we have missed out on so many possible serial killers.

Classic Criteria of Serial Killers

It is still unknown the exact reason why some people become a serial killer while others do not. The average person's involvement in mayhem and destruction begins and ends at fantasy; however, the perpetrator of serial killing, takes it steps further. Miller (2014) determined that fantasies and reaching an orgasmic release drive the need to torture and murder. In the book *Psychopathia Sexualis*, the characteristic such as the motivation of a serial killer is what investigators use today in profiling (2014). Pino (2005) stated that criminologists are too narrow in their studies. They need to focus on motivation, victimization, and social context to explain a serial killer.

It should be noted that there are different variations on how a serial killer commits their crime. Some may rape and then kill or the other way around. Some serial killers like to torture and then kill. There are also those who kill for the pleasure of killing. Moreover, there are those serial killers who will commit all three acts on a victim (Reid, 2017). Now, there is also speculation that serial killers become a killer because of their childhood, their overall environment, mental illness, or all the above. The FBI came up with the typologies; organized and disorganized, which may help explain a killer (2017). However, the list is endless when it comes to classifying a serial killer because there are so many factors. It also appears that there are so many twists and turns that there is no correct answer.

Rossmo (2000) felt that three or more rapes with a cooling off period are considered serial rape. Serial rapists exhibit several patterns of similarity to serial killers, which is hardly surprising considering many of the latter began as rapists and often intersperse murders with

non-lethal sex assaults. Then there are the serial murderers who also rape their victims' post-mortem, which is even more horrifying (2000). Edmund Kemper was known to rape his victim's after death. He would take them home and rape them before dismembering their bodies (Vronsky, 2018). Nevertheless, there will never be an accurate answer as to whether all serial rapists become serial murderers because again, there are so many rapes that go unreported.

Torture has been found in history books dating back to at least 14 AD. Tiberius tortured his victims in various ways that brought pleasure to him while Vlad the Impaler just tortured his victims or enemies for the fun of it. Some research has shown that some serial killers began with torturing animals like Dennis Rader (Vronsky, 2018). Once he perfected his skills, he was ready to torture and kill his victims. Dennis Rader was known as the BTK killer which translates as bind, torture and kill. He would repeatedly strangle and then resuscitate his victims. Jeffrey Dahmer dismembered his victims after killing them, and then ate their body parts (2018). One victim he found so attractive that he kept his remains; head and genitalia with him (Berry-Dee & Morris, 2008).

Most people would assume that most serial killers horribly torture their victims for no reason like Jack the Ripper, however, each serial killer has their own classifications; motive, or modes operandi (Miller, 2014). Many would think that most serial killers torture and then kill their victims; however, a serial killer usually has a motive be it thrill seeking, anger at someone, for money, or they want to be a celebrity (Simon, 2015). For example, David Berkowitz's motive was the thrill-seeking, and most of the female victims had long dark hair. He began his killing spree with a stabbing of two women that went awry, so he switched to shooting his victims mostly in parked cars. He said he was obeying the orders from 'Sam.' (Vronsky, 2018). Or how about Jack the Ripper? He loved being a celebrity so much that he sent letters to media and

Scotland Yard. The 'From Hell' letter was signed "catch me when you can Mishter Lusk." (2018).

Serial killers are not alike, and their typologies are different; some kill for other reasons than sex (Knight, 2006). Miller (2014) stated that typologies also do not consider female serial killers. However, after researching the different typologies, Miller (2014) also asserted that some categories could include female serial killers. One category is the sexual sadist who kills to control, dominate and humiliate another person such as Ted Bundy. Next, there is the delusional who wants to rid the world of bad people such as the Green River Killer, Gary Ridgeway. Then there is the custodial killer who kills helpless or dependent people who look to another person as a caregiver such as Nannie Doss that Telfer (2017) found to be a grandma type. Finally, there is the utilitarian killer who kills for money or material gain such as Mary Ann Cotton.

Male Serial Killers

Researchers have stated that most serial killers are white males, and they are the most oft researched (Miller, 2014). Moreover, this is the basis that researchers have used to identify a serial killer over the past one hundred years. When the FBI began their research in the 1970s, they went to see serial killers in prison such as Edmund Kemper to get a better idea of what makes a serial killer. This is where the classifications and typologies began; looking at and listening to real serial killers. Morton and Hilts (2005) found that male serial killers are sexually motivated and without remorse. Gurian (2017) affirmed that they kill those who are local to their home base and use various weapons. She also stated that most murder by strangling, stabbing, shooting, or wielding a weapon as an instrument. Researchers such as Knight (2006)

discovered that many male serial killers had a childhood where they were either abused or neglected.

Knight (2006) also unearthed that if they were predisposed to violence in their environment, they would turn to criminal behavior. Some researchers like Simon (2015) felt that some serial killers do not have moral values because their parents never taught them. Childhood trauma may also have changed them in their thinking of right and wrong. Therefore, the more they wield power over their victims, the better they feel. Ed Gain's mother was a dominating figure who hated men, especially her alcoholic husband. She deprived her sons and found other women immoral. Regardless, Ed would exhume the women's bodies to create a blanket, a dress, or a mask by using the victim's skin (Simon, 2015). Perhaps he did this because of his childhood environment; rekindling the dominant woman in his life.

Miller (2014) unearthed that most victims are young white females. However, some serial killers have targeted children and the elderly. Many serial killers collect things such as jewelry and clothing from their victims and keep them as mementos of the kill (2014). Miller (2014) also stated that many serial killers partake in postmortem desecration such as manipulation, mutilation, or cannibalism of the victim's body (2014). Regardless, serial killers have unique traces of behavior such as how they attack the victim, the bondage they use, how they would torture their victims, and how they would position the body after death. McKenzie (1995) discovered that most serial killers were raised in an environment of violence. Some were also raised by parents who did not parent at all. These serial killers were also found to be either abused by their parents or had mental problems.

Female Serial Killer

Female serial killers are rare; however, they do exist. Gurian (2017) suggested that female serial killers take more time in killing and for the most part, use poison as their method of choice. She also asserted that they usually kill family members, especially children. Farrell, Keppel, & Titterington (2013) surmised that women have many different motives, but they do not assault their victims sexually. Harrison, Murphy, Ho, Bowers, and Flaherty (2015) asserted that most of these women are considered caretakers, and they like to target the helpless. They also did not normally mutilate, torture, or stalk their victims.

Moreover, they asserted that female serial killers lack emotion and do not usually attach to others either (2015). Miller (2014) felt that Eileen Wuornos was the exception because she was out for revenge and killed only men. However, as Welch (2011) stated, female serial killers have been studied very little, so it is almost impossible to classify them correctly. He also felt that since women are in positions of power now, they may adopt male criminal behavior and attitudes (2011). However, Perri and Lichtenwald (2010) stated that there is not any reliable data to determine how future female serial killers will kill.

Male vs. Female Serial Killers

It is a fair assumption to think male serial killers are different from their counterparts; female serial killers. Male serial killers are usually motivated by anger and are thrill-seeking, while female serial killers are more motivated by monetary gain (Morton & Hilts, 2005). However, there are also similarities. The most important similarity is that both male and female serial killers are a product of their parents, their childhood environment, and the choices they make in life (2005). Another similarity is that both are inexperienced until they gain experience with killing, and they are likely to make very few mistakes (2005). Both groups also select their

victim, control them, and dispose of the body when they are done. In addition, they take many chances that eventually lead to capture (2005).

Interestingly, Harrison, Murphy, Ho, Bowers, and Flaherty (2015) stated that those killers who seek power differ in how they operate. Men tend to torture their victims, and one of the biggest reasons is sex, while women peacefully kill their victims so they can get some payment (2015). Overall, the group of researchers felt that perhaps the issue is more about the differences between the sexes (2015). Even more impressive is the fact that Perri (2015) revealed that even though their methods and motives are gender neutral, their killings may be gender specific. Perri and Lichtenwald (2011) also said that both groups are prone to violence these days.

Mental Health

There are a few primary motivations of a serial killer that are based on gratification such as power, anger, sexual thrill, and monetary gain; however, the one that is least explored is psychosis (Hickey 2014). It can be said that a person's mental health includes social, emotional, and psychological welfare. However, the understanding of a person with a mental illness is a bit vaguer and more confusing because of the sociology of the term (Conley, 2015). Before the 1880s, a person was considered either sane or insane, and if they were insane, they were sent to an asylum. In 1866, a book on Psychopathia Sexualis was written by Richard von Kraft-Ebing that proposes an offender's signature reflects their personality and psychopathology (Miller, 2014). In 1952, the American Psychiatric Association published a manual consisting of 60 disorders. Today, the manual lists 400 disorders, and it is believed that a person's mental illness can be treated like any other illness such as the common cold (Conley, 2015).

A few disorders have been studied by researchers over the years. Two disorders that are considered to be more mainstream are attachment theory and psychopathy (Levy & Blatt, 1999).

Another disorder that has been studied is the paraphilic disorder, which includes criteria such as fetishism, sadism, and machoism (1999). Psychotic disorders are also a common mental illness (Levy & Blatt, 1999). The Macdonald triad disorder is a more recent disorder that has been researched.

The attachment theory is about the bonds a child makes with his caregiver in infanthood (1999). The contact between them affects a child neurologically (Somerstein, 2008). Grady, Levenson, and Bolder (2017) looked at the attachment theory and sexual offending and concluded that the lack of a healthy childhood has adverse effects on a person into adulthood. In turn, this can lead to not having a tolerance for others sexually; sex offending. Aileen Wuornos could be considered a child without attachment because her mother left her, and her grandparents treated her as if she did not belong anywhere (Arrigo & Griffin, 2004). Perhaps the adverse effect led her to kill men.

The term psychopath was replaced with a sociopath in 1952; however, over the next years, researchers used both terms to explain those with a personality disorder (Ramsland, 2005). Dr. Robert Rieber asserted that a psychopath has no control over his conscience, so he is not capable of concern for others. He also stated that they dissociate and have no emotions; however, some can appear to adapt to society (Ramsland, 2005). Psychologist Robert D. Hare developed the Psychopathy Checklist and asserted that psychopaths are cold, calculating, and they do not have a conscience (Montillo, 2015).

Paraphilia can be said to be a deviant sexual activity that reoccurs over some time (White, 2007). This may include having a fetish such as collecting women's underwear or licking women's feet, transvestitism, exhibitionism, or voyeurism (Miller, 2014). Some serial killers can possess multiple paraphilias, such as Albert Fish and Jeffrey Dahmer (White, 2007). Richard

Chase also had multiple paraphilias such as schizophrenia and sadism (White, 2007). Researchers have suggested that a serial killer can have on average three to five paraphilias, which would begin around fourteen years of age (Abel, Becker, Cunningham-Rathner, Rouleau, Kaplan, & Reich, 1988).

Psychotic disorders are a category of mental illness that is commonly familiar and frequently seen in books and other media (Levy & Blatt, 1999). Psychotic disorders are severe disorders such as bipolar disorder, schizophrenia, and borderline personality disorder. At times, people with these disorders cannot function in society. Typically, they are delusional and hallucinate to the point that they disassociate from reality (Ramsland, 2005).

The Macdonald triad named after J.M. Macdonald is an example of a more recent mental illness. It is composed of at least two psychological problems, such as cruelty to animals, bedwetting, and fire setting (Walters, 2017). In 2017, Walters concluded in his study that fearlessness correlated with animal cruelty and fire setting correlated with disinhibition, which shows these offenders eventually become antisocial in adulthood.

There is a small amount of research on the mental health of women who commit violent crime (Harrison, Murphy, Ho, Bowers, & Flaherty, 2015). In 2004, Arrigo and Griffin (2004) affirmed that Aileen Wuornos had attachment disorder and psychopathy. During Aileen's childhood, she was abused and neglected by her caregivers; first by her mother and then her grandparents. So, she did not have anyone to form an attachment to when she was young. She also never formed any real attachments when she was older, which fueled her psychopathy.

The researcher determined that female serial killers show a mixed personality disorder (Frei, Vollm, Graf, & Dittman, 2006). They also discovered that the female serial killers they studied were neglected and maltreated in childhood (2006). Harrison and his colleagues verified that

one in ten of their female subjects experienced severe childhood trauma and at least 40% had some form of mental illness (Harrison, Murphy, Ho, Bowers, & Flaherty, 2015).

Gacono (2000) asserted that there is a connection between psychopathy and violent crime. Richard Speck was diagnosed by some psychiatrists as a psychopath because of his casual attitude killing people (Ramsland, 2005). Dr. Essi Viding led a study on antisocial behavior in teens and suggested there can be possible prevention if the child was diagnosed at a young age (Berry-Dee & Morris, 2008). Norris (1998) believed that these offenders kill because of a genetic effect. Morton, Tillman, and Gaines (2014) determined that only 36% of their 92 serial killers were diagnosed with a disorder prior to arrest. Only 42.9% of the offenders were found to have a personality disorder, 19% found with a psychotic disorder, 11.9% found with a developmental disorder, and 11.9% found with a mood disorder (2014). Therefore, considering the connection between crime and the mental illness of the offender, it is likely that a serial killer's mental illness may affect the choices they make during their criminal activity. This leads to the possibility that their mental illness would also affect where they dispose of their victims.

Intelligence Quotient

Many researchers and educators assert that measuring an individual's intelligence can be accomplished by a series of tests (Carter, 2007). Carter (2007) states that 100 is the normal range, and a child's intelligence remains constant through childhood and tends to have little improvement after the age of eighteen. Conley (2015) also stated that a test can measure intelligence; however, many sociologists feel the test is biased in that it focuses on the dominant group in society and it does not measure innate intelligence.

The FBI developed two core classifications when referring to a serial killer; organized and disorganized (Simon, 2015). The organized classification includes an offender who has above

average intelligence such as Ted Bundy. He was intelligent and methodological in his capture and killing. He evaded law enforcement for years (Simon, 2015). However, the disorganized classification includes an offender who has an average or low IQ (Miller, 2014). Psychiatrist Marvin Zipornyn diagnosed serial killer Richard Speck as having an IQ of a ten-year-old and said that he showed signs of brain damage (Ramsland, 2005).

Therefore, considering the FBI's connection between crime and the intelligence quotient of the offender, it is likely that the serial killer's IQ may affect the choices they make during their criminal activity. Employment location and the preferred victim may also impact where serial killers hunt for victims. Even so, this leads to the possibility that their IQ would also affect where they dispose of their victims.

Intelligence Quotient and Mental Health

IQ and some sort of mental health disorder such as psychopathy are always linked when looking at the FBI's organizational classifications; however, few studies have focused on their relationship definitively. An exception to this gap is work by Mortenson, Sorensen, Jensen, Reinisch, and Mednick (2005), who indicated that a low IQ has a strong association with a mental health problem. Oleson and Chappell (2012) pointed out that there is little known about above-average and genius-level intelligence and crime because it is rarely researched.

While researching high and low intelligence, some researchers looked at some factors that could contribute to someone also having a mental disorder. Ryland, Lundervold, Elgen, and Hysing (2010) proposed that children with a chronic illness have a higher risk for a mental health disorder. They also showed that there is a protective factor when someone has a higher IQ, so there is only a small percentage at risk for a mental disorder (2010). Therefore, IQ and mental

health disorders are associated and monolithic; however, having a low IQ does not always mean that a person will have a mental disorder or vice versa.

Cross Culture Comparison

It would make sense to say that different cultures breed different serial killers; however, studies have shown that there are many similarities and only a few differences. Most notably are the similarities in the classifications of serial killers (Simon, 2015). They mainly are similar in behavior, regardless of where they live. They choose the same type of victim and are motivated to commit crimes the same way as well. Their methods are also the same. Researchers compared a serial killer in Italy and one in Michigan. They found that both were very similar in behavior, motivations, and methods. Furthermore, the two serial killers also picked the same type of victim (Sorochinski, Salfati, Labuschagne, 2015).

On the other hand, Sorochinski's group found that the differences are not so distinguishable (Sorochinski et al., 2015). For example, British serial killers such as John Duffy and David Mulcahy who were serial rapists and murderers. They used the train as their mode of transportation, and they hit places along the railway. This is not something that you can do in the United States. Therefore, in comparing them to Americans, transportation can be a contrast (2015). The environment may have also impacted how they committed their crimes and what weapon was more accessible. The physical environment may also influence the decision of where to find their victims and how to dispose of the body (2015). The researchers also asserted that the subconscious mind of the serial killer might have some impact on how they interact with their victim. Considering the possible differences, one cannot be sure how people behave in other countries (2015). The results showed that the killers were similar despite the different places and behaviors. The one significant difference is how the killer planned to kill their victim. It was

easier for South African offenders to be spontaneous because of the environment they live in there. The United States offenders were found to plan ahead of the crime as well as after the crime (2015). This one difference may be associated with different environments.

Culture and Societal Views

Quinet (2007) found that all kinds of media made money from the public's interest in these types of crimes. Before they were named serial killers, culture was not sure how to handle serial killers. In the 1400s to 1900s, they did not ask why or find out the motive; they would hang them (Vronsky, 2018). Scrivener (2005) discovered that since the Victorian era, people indulge in voyeurism and love to hear tales of crime mayhem. Most believe that Jack the Ripper changed how the public viewed serial murder; people became fascinated with serial murder. However, over time, that fascination dissipated or at least until the 1970s (Jenkins, 2005). Jenkins (2005) unearthed that newspapers, magazines, and books were filled with spectacular crimes in midcentury, so when there were multiple murders, the public was fascinated by the gruesome crimes.

Today, society is spellbound by criminals and their crimes. There are countless movies, books, and websites that are dedicated to serial killers in one form or another. People are bombarded with serial killers in that one begins to wonder the impact it has on a person (Jenkins, 2005). Indeed, Miller (2014) discovered that the public's interest is so great that serial killers are considered movie stars. They appear in movies and television, song lyrics, and having all types of memorabilia.

Rafter (2007) called it popular criminology, and she felt we should be concerned with the perception and impact it has on the public. She found that even though people may hate serial killers, they are also fascinated by them, and sometimes this is where the people get their ideas of

crime. Scrivener (2005) suggested that serial killers became celebrities in America in the mid-twentieth century. Scrivener also stated that we either have the monster or the charming guy next door. Most of our knowledge comes from Hollywood productions about serial killers such as Ted Bundy (2005).

Hickey (2004) felt that people in the 1960s were attracted to what was happening in real life which is why we have films such as *Psycho* that could be portraying Ed Gein's life or *The Strangler,* that portrayed Albert DeSalvo's life. Morton (2005) said that the public interest was renewed in the 1970s by such killers as the Green River Killer, Ted Bundy, and BTK. In the 1990s, the public was back for another film; *Silence of the Lambs*. Ed Gein was the inspiration for Hannibal Lector (Miller, 2014). Serial murder took over television with shows like *Criminal Minds* and HBO's *Dexte*r (Forsyth, 2015). More recently is the show *Mindhunter,* which portrays the FBI's Behavioral Science Unit in its beginning stages of identifying serial killers (Douglas & Olshaker, 2017).

Many examples can also be found in books and the internet. There are countless books about serial killers such as Ted Bundy, the Green River Killer, and Dennis Rader. The internet has a host of places to visit, whether in places like Wikipedia, sites about any serial killer, or YouTube. Wikipedia has lists of serial killers from different countries. A person can also go on google and type in 'serial killer' or 'Jeffrey Dahmer' to get numerous sites to view. On YouTube, you can pull up documentaries on serial killers. There are also websites dedicated to a serial killer. Besides, there is a YouTube group called 'Murder with friends' where they talk about various murderers such as the Columbine killers, Ted Bundy, the Craigslist killer, and Casey Anthony.

Political View of Serial Killers

In the early years, the news did not travel like today, so law enforcement had more leeway in disposing or hiding the crimes unless it benefited them politically. If you look at the FBI's handling of serial killers, they panicked when it first came out in the news of what they were doing (Douglas & Olshaker, 2017). Before the news got ahold of it, it was a secret. Even when it came out, they hustled to cover it up or at the very least downplay the crime (2017). However, public fear of serial killers sparked political and economic capital for law-enforcement agencies such as the FBI (Scrivener, 2005). The serial killer provided justification, and it helped the FBI insert itself into local law enforcement to use their new tool of profiling serial killers (Douglas & Olshaker, 2017).

Nevertheless, Quinet (2007) found that the FBI wanted their Behavioral Science Unit to have authority over important cases such as serial murder. Later, the media made serial murder popular, which helped the FBI through some scandalous years of failure, such as Ruby Ridge and Waco (Scrivener, 2005). Therefore, you end up wondering if the numbers of serial killers were exaggerated.

Scrivener (2005) also found that feminists focused on serial murder to highlight the victimization of women in the media to further their cause. Eschholz and Vieraitis (2004) stated that feminist theory states that when there is greater inequality, there may be more rapes. Some researchers believe that women are property and they are placed here to meet the needs of men (2004). Whaley and Messner (2002) believe that once women are seen as equal to man, rapes will decrease.

Then you have the death penalty advocates who used serial murder to help make stricter sentences. Some religious groups also used serial murder to warn the world of Satan (Scrivener, 2005). Nevertheless, today, it appears that politicians want to stay clear of the term; they have

more pressing matters to deal with when it comes to the public (2005). For example, after the mass shootings that have been happening at schools over the past ten years, the terms serial killer or serial murders have disappeared in the media.

Significance of Studying Serial Killers

Despite the macabre interest, serial murder is an uncommon occurrence. Past studies show that serial murder is only a small percentage of murder (Tully & Smith-Inglis, 2018). However, that still does not explain why they commit those types of crime. It also does not account for all those missing or unidentified people who could have possibly died by the hands of a serial killer. Also, it cannot imagine the social or psychological impact it has on the population at hand. If law enforcement had as many tools that it could have to solve these types of crimes, the world would be one step closer to solving many serious crimes. So, if one more tool contributed to the apprehension of these types of killers, why not use it? There is one tool that could help law enforcement.

Geographic Profiling

If the number of serial sexual crimes is so high and continues to be a steady enterprise for some, is there a way to pinpoint the residence or home base of the offender? "Geographical patterns in crime have been noted since the mid-19th-century pioneering work of Andre-Michel Guerry and Lambert-Adolphe Quetelet who mapped, on a national basis, violent and property offenses and examined their spatial relationship to poverty" (Cited in Rossmo, 2000, p. 98). In more recent times, geographic profiling has been discovered and designed as a method for profilers to support and use to capture serial offenders.

Therefore, "it is the use of crime locations to understand the offender and propose where he might be living" (Canter, 2003). Rossmo (2000) asserted that many areas should be considered

when finding a serial killer such as the locations of the crimes, how a serial killer gets to each crime location and the victim. The present paper evaluates whether geographic profiling is useful in tracking and capturing serial offenders.

Geographic profiling has been used by a few major police stations, such as the New York Police Department in the United States and the Vancouver Police Department in Canada (Rossmo, 2000). In 1990, the Vancouver Police Department established the world's first geographic profiling software and it has assisted in at least 100 investigations. This includes agencies such as Scotland Yard in England, the FBI in the United States, and the RCMP in Canada (2000). In 2018, Cooper, Schmitz, Captain Byleveld, and Dr. Rossmo found that using geographic profiling was helpful to the Wemmerpan serial killer case in court by showing the maps to the jury.

Canter, Coffey, Huntley, and Missen (2000) discovered that using geography to profile serial crimes started with the circle hypothesis. This hypothesis states that the offender lives within the circle defined by a diameter drawn between offender's two farthest offenses. This is one reason why computer software programs were invented to improve the method. These software programs are costly, but the few who can afford them have been able to utilize them by zeroing in on a radius of where the serial offender's possible residence is located (2000). Rossmo (2000) unearthed that at least 30% of police agencies use some type of mapping software for their crimes. He also unearthed that law enforcement has started to use GIS experts over the past 15 years (2000). However, these police stations do not use it to apprehend serial criminals but for jobs such as mapping crime and finding hot spots for high crime activity (2000). Nevertheless, there are a variety of new software tools on the market that are used to locate serial offenders,

and the ones that are recognized and most widely used are Predator, CGT, Rigel, CrimeStat, and Dragnet. Each will be discussed below.

Geographical Profiling Software Programs

Dr. Maurice Godwin, who works with psycho-geographic profiling, is one of a few who works to capture serial offenders. He developed a GIS software program, Predator, which has not yet been commercialized or shared with anyone else outside of his field. It relies on a mathematical algorithm that takes pieces of the crime scene and assesses interrelationships among them to emerge into coordinates which are then put into a Universal Traverse Mercator grid system (Rossmo, 2000).

CGT (Criminal Geographic Targeting) is a computer program developed by Dr. Kim Rossmo at the Simon Fraser University along with the police department in Vancouver that assesses the spatial characteristics of an offender's crimes. Turvey (1999) asserted that it produces a topographic map that assigns probabilities to different areas for the location of the offender's residence or, anchor point within the community. Rossmo (2000) stated that it consists of the possible place where the serial offender encounters the victim, the murder scene, the dump site, or all three. It also considers how the offender thinks and works. The outcome is a map or geoprofile, which gives a search area for authorities (2000).

Dr. Rossmo also designed Rigel, which would incorporate analysis, GIS, a database, and visual tools into the software. This software focused on possible crime locations such as the possible place where the serial offender encountered the victim, or where the murder took place, or the dump site. This software uses the street address and finding the latitude and longitude of the address (Rossmo, 2000).

Santtila, Zappala, Laukkanen, and Picozzi (2003) affirmed that the software, CrimeStat, was created by Dr. Ned Levine and it makes statistical predictions concerning the likelihood of different locations containing the home base of the offender. The predictions are based on a selected distance-decay function, which is applied to each of the crime locations. Rossmo (2000) stated that the distance decay function is the reduction in the probability of spatial interaction with the increase in distance. The summing of the values is then applied to each location, and a probability is given and placed in a grid which finally can be imported to a GIS system to produce the map (2000).

Snook, Canter, and Bennell (2000) discovered that there is also the Dragnet software program, developed by Dr. David Canter who is a psychologist at the University of Liverpool. This software uses the distance-decay function selected by the user from the negative exponential family. With all these new software programs and innovations, geographical profiling has become an addition to the improvement in the capture of serial offenders; serial killers and serial rapists.

Accuracy of Geographic Profiling

As early as 1970, investigators started recognizing that serial offender's residences lie within the center of their crimes. Research on serial rapists has shown the reliable of strong and consistent patterns are found in various ways (Rossmo, 2000). Offenders consistently commit a crime in a familiar neighborhood or a place that looks like their neighborhood (Rossmo, 2000). Canter, Coffey, Huntley, and Missen (2000) stated that a study was done in 1995 and 1998, and both found 56% of serial rapists were found in the circle. Warren, Reboussin, Hazelwood, Cummings, Gibbs, and Trumbetta (1998) found that 29% of 299 rapes occurred within a mile of the rapist's residence, 51% within 2 miles, and 76% within 5 miles. Another study found that 83

out of 108 of the serial rapists traveled less than 20 miles. Canter and Gregory (1994) showed that computer software using circular regions was successful in finding where the offender lived. Canter and Hammond (2006) asserted that many serial rapists live close to the center of their offense locations.

> It was found that of their 108 rapist cases studied, 83 raped traveled on average, 3.14 miles to commit their rapes. The closest distance was, on average, 1.7 miles, while their farthest distance traveled was, on average, 4.9 mi. Interestingly, while the mean closest distance was 1.7 miles, almost one-half (40 rapists) of all rapists raped at least once within 0.5 miles of their home. (Cited in Warren, Reboussin, Hazelwood, Cummings, Gibbs, and Trumbetta 1998 p. 46-47).

The few studies on serial killers have been executed by researchers to prove the accuracy of geographic profiling. Canter, Coffey, Huntley, and Missen (2000) state that a study from Hodge in 1998 found 86% of the 126 U.S. serial killers work within the circle. In another study, they found that 79 serial killer's residences were located within the search area of the circle. Santtila, Zappala, Laukkanen, and Picozzi (2003) discovered that the "center of minimum distance was a relatively good prediction of the actual home base of the offender" when they used the murders and attempted murders of the Yorkshire Ripper. Unfortunately, serial killers have yet to be studied to the extent that they should be in order to have an accurate answer to the question of accuracy (2003).

Limitations of Geographic Profiling

Geographic profiling is based solely on known crime locations. Consequently, deficiencies in this research are possible. The FBI states that the primary serial crime is committed closest to the offender's residence (Rossmo, 2000). With that in mind, data that is missing or incorrect

could give an inaccurate reading for the area for the crimes. Generally, Rossmo (2000) asserted that at least 90% of the information should be accurate. It has been stated that with serial murder, there needs to be a minimum of five crime locations to put out a certain search area. As a result, the only hope is to wait until an offender has committed at least five crimes.

There is also "linkage blindness," which is the inability to link a series of crimes to an offender. The traits to link them are not always directly observable to the investigator so one or more crimes can be left out, which may again give inaccurate data on the geographic area (Turvey, 1999). Moreover, many rapes and missing persons go unreported, which would add to linkage blindness. Furthermore, Mott (1999) found that crimes may occur in other or between jurisdictions in which the offender traveled, allowing traveling to be an effective weapon against identification. These crucial murders could be detrimental in getting a specific search area.

Another possible deficiency is that many researchers do not believe in the significance of the places the offender chooses for his/her victims (Rossmo, 2000). They may feel that encounter sites or dumpsites are not reliable enough clues and evidence to help in the capture of the offender (2000). Moreover, they do not always see the possibility that other factors like victimology, the study of victims and their behaviors and actions, or the psychology of the offender factor into the capture of a serial offender. It has been stated by Rossmo (2000) that a geographic profile is only one part of what is usually a long and complex police investigation.

One more serious deficiency to observe is the home base, usually the residence of the offender, and what it really means. Canter (2003) discovered that the serial offender's home base is usually his residence; however, it may also be the home he grew up in or where he lives now. It acts as an anchor, allowing him to kill and return with little bother (2003). Lundrigan and Canter's (2001) investigations reflect that psychologically the home is essential, and the

offender wants to be safe psychologically as well as geographically. An example of another base could be his girlfriend's home, or the place where he or she works, or a movable vehicle such as an RV (Rossmo, 2000). Even so, when geographic profiling is used as a tool, it can offer a possible direction for law enforcement officers.

Significance of Geographic Profiling

This is an essential study since a large number of serial offenders continue to commit their crimes undetected. Furthermore, it could show that geographic profiling has helped solve crimes. Considering the number of sexual offenders, this could be a tool in the capture of these individuals. Turnbull, Hendrix, and Dent (2000) found that many serial killers come from the Midwest, such as Illinois and Ohio.

This study intends to show that geographic profiling is beneficial in the capture of serial offenders by showing spatial patterns and a general location of the offender's residence. Besides, the results will be used to add to the increasing study of geographic profiling. Society needs to know that the authorities are utilizing all tools to capture serial offenders and create a safer environment for future generations.

The importance of geographic profiling is that it is a tool to help determine at least one avenue of investigation in a particular area such as finding the known serial predator or offender. The place an offender leaves his/her victims is also significant in the search for the predator. This may not work alone; however, with all the other information collected, the pieces will come together to form a profile that can only help and not hinder an investigation. Consequently, to choose a strategy that reflects an offender's psychological, as well as geographical profile, may give a better understanding of them and could lead to their identity and capture.

However, some studies also have concluded that some home bases are outside of the area predicted or are mixed (Canter, Coffey, Huntley, & Missen, 2000). Canter, Coffey, Huntley, and Missen (2000) found that there are likely to be instances where actual locations such as parks, lakes, or zoos are located within the area. Also, Santtila, Zappala, Laukkanen, and Picozzi (2003) stated that the possibility of finding associations between traveling behavior and crime scene behavior should be further explored.

If you look at how a serial killer works, you will notice that the majority rarely move from one residence to another. Perhaps they do not want to call attention to themselves. However, it can be noted that human behavior calls us to stay where we are most comfortable (Lundrigan & Canter, 2001). Therefore, perhaps a serial killer needs to stay in a place they feel comfortable. Most serial killers also operate alone and use the same signature. To deviate from the standard means to possibly be captured. There are not that many serial killers who travel to kill; the majority are sedentary (2001).

Nevertheless, there are different perspectives on serial killers. There are also not many studies done with female serial killers. Perhaps the reason is that there are so few of them. Alternatively, perhaps it is not easy to detect a female serial killer because of their method of killing. Overall, these are factors that should be explored.

In conclusion, every serial offender is different; however, if more than half are caught with the help of geographic profiling, this is an improvement. Not every device performs accurately one hundred percent of the time. Consequently, Rossmo (2000) felt that a geographic profile could be useful when it is used by law enforcement. Overall, the computer software programs have fundamentally helped more than hindered in the cases studied.

Research Questions

1. Does geographic profiling aid in serial murders?

2. How relative is the residence of the serial killer to the dumpsites?

3. How relative is mental health and intelligence with the radius of the dumpsites to the serial killer's residence?

III. THEORETICAL OVERVIEW

Spatial Data Analysis & the Circle Hypothesis

Spatial Data Analysis

Spatial analysis can be found beginning in the 1950s and used in geographic information systems. Haining (2003) states that spatial analysis uses techniques that store each data value set. Haining (2003) also defines spatial as "each item of data has a geographical reference, so we know where each case occurs on a map" (p.1) which is either data from a surface or an object. Therefore, the data can be a set of fixed locations on a surface such as fog or points located in the geographic area, such as a restaurant (Haining, 2003). The analysis would focus on the variation in an area such as crime data.

Haining (2003) found that spatial analysis has three models, which include cartographic modeling, mathematical modeling, and spatial data analysis. Cartographic modeling is classifying the areas in a given area on a map (2003). Mathematical modeling is the interaction between objects, and spatial data analysis is the use of spatial referencing (2003). In the 1980s, the United States National Center for Information and Analysis focused on spatial data accuracy (Goodchild and Gopal, 1989, Cited in Haining 2003, p. 6). Some researchers developed a geographic analysis machine looking for events clustered together (Openshaw et al., 1987, Cited in Haining, 2003, p.6). In the 1990s, the Bayesian approach was simplified and the Geographic

Information Systems gained popularity because of all the functions it could perform, the storage capacity, and the inclusion of statistic results. This expansion in the field gave way to explaining health behaviors and looking at the role of spatial relationships in explaining offender behavior (Haining, 2003).

Now Bauer, Hering, Raschke, & Thierbach, C. (2014) discovered that there are three types of method approaches to spatial analysis. First, the use of Ethnography as an approach has focused on social research and culture studies. Secondly, the use of surveys as an approach is also in the field of sociology in cross-national research. Finally, the use of maps and cartographic approaches began in the last ten years with the focus on geographic information systems. This approach, along with an understanding that space is created by human behavior, yields the best results (2014).

Tita and Ridal (2010) stated that Arthur Getis was a profound figure when it came to studies in spatial analysis, and he stated that there had not been significant work in the area since the early 1970s. However, Tita and Ridal's (2010) research indicated that it has proven that negative health issues happen in a specific area. It also has been used to prove that gangs and crime happen more often in certain areas because of social interaction in that area (2010). Block (1979) unearthed that poor and middle-class neighborhoods have higher rates of crime. McGrath, Perumean, and Sloan's (2012) research indicated that university campus crimes differed depending on the area. Haining's (2003) research found that the focus on geography and it is subfields like the geography of crime is essential in explaining these types of issues.

More recently, the Spatial Analysis theory has been used with a focus on geographical analysis that seeks patterns of human behavior. Hogh-Olesen (2008) uncovered that there had been plentiful studies on human spatial behavior when it relates to the spacing between

individuals; however, significant areas have been neglected. In 1949, Zipf's (1949) research found that people do not exert much physical energy into the desired activity. Ratcliff (2012) indicated that they prefer to stay near their home because it is familiar. Bottoms and Wiles (1997) coined the term environmental criminology to show the relation of places and activities on an individual and crime. Tita and Radil (2010) discussed that the spatial distribution of crime does not move into other areas, but instead stays within a specific area. They saw that using the geographical information software showed that crime does not move to another area across town but may move to an adjacent area; still within what some may say is a comfort zone. Tita and Radil (2010) also noted that crime does cluster into one space.

This study focused on the idea of place or space and how it plays in crime geographically; the place where a serial killer currently lives and the place where he/she commits the crime. Tita and Radil (2010) unearthed that defining place within geography has been a struggle for scholars because it could involve a physical location or perhaps a social location. Therefore, this is why this study has taken the stance that a person constructs the places through human activity and familiarity. People are creatures of habit and usually stay within their area to shop, get gas, and eat out because the places are considered safe psychologically and geographically (Lundrigan & Canter 2001). Bernasco with Luykx (2003) and with Nieuwbeerta (2005) asserted both times that the locations of an offender's crimes are determined by the offender's activity and awareness of their space. It is apparent that there is spatial decision making in human behavior, so crime is just another factor in a person's decision.

Circle Hypothesis

The Circle Hypothesis is relatively new and was developed by Cantor and his team. In 1993, Cantor and Larkin (1993) tested the theory that offenders work within a fix location by using a

circle and found that most of the serial rapists stayed within the area. Cantor then went on to replicate this theory with different teams and found the same result. Cantor, along with Coffey, Huntley, and Missen (2000) found that using geography to profile serial crimes started with the circle hypothesis. This hypothesis states that the offender lives within the circle by focusing on the offender's two farthest offenses. For this reason, computer software programs were invented to improve the method. Kocsis and Irwin (1997) discovered that the circle hypothesis was successful in Australia when they tested and found that 70% of serial rapists offended within the circle. In the same year, researchers Tamura and Suzuki (1997) determined that offenders stayed with the circle. In 1998, a study from Hodge found 86% of the 126 U.S. serial killers work within the circle. Rengert, Piquero, and Jones(1999) stated that as the distance from the offender's home increases, the offender is less likely to offend. In another study, they unearthed that 79 serial killer's residences were located within the search area of the circle (Cantor, Coffey, Huntley, & Missen, 2000). In 2007, Cantor and Hammond's (2006) study showed that the offenders lived close to the center of the circle. In 2013, Cantor had a team again with Hammond, Youngs, and Juszczak and they focused on the smallest area and predicting that it was the offender's home and found that it these systems perform better than human judges (Cantor, Hammond, Youngs, & Juszczak, 2013).

In contrast to most of the previous studies that focused on the geographic software system and serial killers, this study also evaluates the spatial behavior of the serial killer. There are not many studies that focused on the spatial behavior of a serial killer and how they are like everyone else and stay close to home as a habit and for safety (Lundrigan and Canter, 2001). In conjunction with spatial behavior, this study evaluates how the killer stays within a circle or a certain distance of their home base.

IV. METHODS

Mixed Methods

This study tested the effectiveness of the geographical profiling systems by addressing whether this system will be useful in the search for serial killers. Serial killings are considered a rare crime at this time; however, the killers are very complex individuals who tend to operate in a pattern and stay within a specific area to commit crimes. A study from Hodge in 1998 that showed 86% of 126 serial killers stayed within the circle, which translates that they stay within a particular area. Problems and limitations are possible in this type of study because it cannot encompass the few serial killers who travel distances to kill. However, most serial killers follow a pattern in their behavior and stay within a comfort zone. Another study found that the serial killer's homes were located within the hypothesized circular area (Rossmo, 2000).

This study utilized a mixed methods approach. Researchers defined this approach as "the type of research in which a researcher or team of researchers combine elements of qualitative and quantitative research" (Cited in Burke Johnson, Onwueegbuzie, & Turner, 2007, p. 123). One researcher defined mixed methods research as a combination of qualitative and quantitative research (Creswell, 2015). Creswell, Plano, and Clark (2011) felt that the approach could give a greater understanding that a single approach would lack. They argue that four types of research have benefits and challenges in the mixed methods approach that can be utilized such as the triangulation design, the embedded design, the explanatory design, or the exploratory design (2011). Triangulation design is particularly relevant to this study because the focus is to gather the qualitative and quantitative data for an overall interpretation of the findings. Almalki (2016) found that defining mixed methods is not an easy feat since there are have plenty of definitions

to pick from; however, he felt that the overall approach provided a better area to investigate using words and numbers to the benefit of the other.

Nevertheless, the approach utilizes qualitative research which places importance on "the meaning individuals or groups ascribe to a social or human problem" (Creswell 2014, p.4). Korstjens and Moser (2017) proposed that this can include interviews or discussions with a particular group. Aliaga and Gunderson (2000) added that the use of qualitative research in mixed methods approaches could allow for the collection and analysis of data using some mathematical method such as statistics. The CrimeStat software uses spatial statistics to analyze the locations of the serial killer's residence and the dumpsites.

The use of the mixed methods methodology was not only to gain an understanding of the problem but also to use the measurable data and explain the data. The approach focused on case studies and the geographical information system software together. Using case studies, this study focused on the evidence, appraised the value of it, and used it to understand the significance of geographic profiling software in aiding in the capture of serial sexual offenders.

Case Studies

Guetterman and Fetters (2018) stated that case studies are an idyllic approach. Yin (2014) proposed that a case study is the intention to analyze and get a better understanding. He also found there are four types of case study designs; single case design, multiple case design, holistic design, or embedded design (2014). Multiple case design is relevant to this study because the focus is on comparing and contrasting the results of five case studies. Guetterman and Fetters (2018) further state that many mixed method approaches utilized a case study for the qualitative component. Yin (2014) found that applying more than one case yielded better results.

This case study involved a detailed investigation and examination of a serial killer. A focus on serial killers was selected for several reasons. One was that serial killers could evade law enforcement and profilers. The second reason is that even though serial killing is a rare form of homicide, it can reveal the motivation and other underlying currents that could affect how law enforcement and criminologists view serial crimes. Finally, the impact of their behavior on where they commit those crimes can also be very revealing in the capture of serial offenders (Rossmo, 2000). Brantingham and Brantingham (1993) suggested that offenders are influenced by their activities and their awareness of the spaces that surround them.

Data Collection

This study consulted published, and peer-reviewed texts and articles on serial killers in the United States and a list was made of the cases with adequate information. Much of the data collected was first taken from the book "Geographic Profiling" written by Dr. Rossmo, which collected data from the FBI NCAVC (National Center for the Analysis of Violent Crime). The data collected was then verified from texts on the serial murderers. The verification of the serial killer's information came from at least two sources to eliminate potential bias on the serial killer's residence and dumpsites of their victims.

Five serial murderers were chosen that fit the following criteria; male, the serial killer committed the crimes after the age of 18, the murders occurred between 1960 to the present day, between four and fifteen victims were found, the address of the dumpsites were known, the serial murderer lived at the same address at the time of the murders, the serial murderer operated alone, and the serial murderer used the same signature (Rossmo, 2000).

After acquiring the data such as the address of the body's disposal site, dates of murders, and offender's residence, the sites and residence data was entered into a street maps application to get

the longitude or 'X' and latitude or 'Y' coordinates. The data collected was then put into an Access sheet of the longitude and latitude coordinates of the serial killer's address during the crimes and the dumpsites of the victims. The Access sheet was then entered into the geographic profiling software and ArcGIS mapping software to produce the map.

Geographical Profiling Software

After researching the five known geographical profiling software systems, it was determined that the best software system for this study was CrimeStat. The main reasons were the cost of the software and availability. The software is free to the public. It can be easily found and available to download from online along with the manual (Heraux, 2007). It is also easy to use. Finally, it also considers new ideas for research and adds in updated versions of the software.

CrimeStat has many types of files to choose from depending on the type of analysis that the researcher plans to use to perform an analysis. Once a file has been picked that works best for the analysis, and the data on longitudes and latitudes were given variable names to put into the primary file so the information can be compared. A reference file then produces data for analysis (Heraux, 2007). The data is then put into ArcGIS to print out a map of the sites, the mean, and distances that would then be used to produce a circle.

CrimeStat has three components: spatial distribution of data, spatial modeling, and crime travel demand modeling (Heraux, 2007). The spatial distribution is used to show the distance between the points of data and analyzing things like hotspots. The spatial modeling uses systems like the kernel density estimation, which is commonly used for identifying hot spots of crime (Santos, 2013). Overall, it allows for simple analysis to more detailed analysis depending on the research needed (Heraux, 2007).

This study did a simple analysis using only the spatial distribution of data and spatial modeling. The spatial distribution showed the basics such as the distances between the points while the spatial modeling showed the three-dimensional density analysis of the points. The five serial killers' documentation of their home location and dumpsite location were inputted into CrimeStat for the statistical analysis. The results were saved in text files, which included the X and Y coordinates of the sites, the mean center, standard deviation, and the minimum and maximum distances. The X coordinate represented the longitude while the Y coordinate represented the latitude and these coordinates represented a single location such as a dumpsite of the serial killer's residence. The mean center was the center of all the points on the map. The standard distance deviation is the average distance between the points. The minimum and maximum distances create the boundaries of the points; which are the two furthest offenses. These results were documented and then put into the ArcMap software; owned by ESRI, using the National World Map and base map imagery for the visual analysis. This analysis ends up showing whether the serial killer's residence and dumpsites fall with the circle.

Cantor and Larkin (1993) tested the theory that offenders work within a fix location by using a circle and found that most of the serial rapists stayed within the area. Cantor then went on to replicate this theory with different teams and found the same result. Canter, Coffey, Huntley, and Missen (2000) discovered that using geography to profile serial crimes started with the circle hypothesis. This hypothesis states that the offender lives within the circle defined by a diameter drawn between that offender's two farthest offenses. This is where computer software programs were invented to improve the method. These software programs are costly, but the few who can afford them have been able to utilize them by zeroing in on a radius of where the serial offender's possible residence is located (2000).

V. RESULTS

(A) Case Studies

The purpose of my study was to show that geographic profiling assists in serial murder cases, by looking at the significance of disposal or dump sites, the residence of the killer, and the distance between the dumpsite and the serial killer's residence. Using the mixed methods approach, this study focused on the case studies of five serial killers and analyzed their content. It also added an additional component; the examination of the extent to which mental health and intelligence may mediate an offender's decision regarding the location of the dumpsite. The case studies and geographic profiling software applied to the following five serial killers: Richard Cottingham, Robert Lee Yates Jr., Bobby Joe Long, Richard Ramirez, and Richard Trenton Chase. Each serial killer was researched and geographically profiled for this study.

Richard Cottingham was born Richard Francis on November 25, 1946. He had a hard childhood because he spent most of his time at home helping his very controlling mother. In high school, he was a track athlete. He had a fascination with bondage and sadomasochism; psychiatrists consider this a mental disorder. He had an icy grin and kept things to himself. He appeared shy and an underachiever to outsiders, however, he was highly intellectual. He was employed as a computer operator at Blue Cross-Blue Shield of Greater New York and was married with three children.

Richard was a textbook sadistic serial killer. Unfortunately, there is little known by psychiatrists about Richard because he refused to talk throughout the years until he confessed to a murder in 1967. Nevertheless, it was evident to researchers that he loved to torture because of what was left at the crime scenes. One interesting fact is that his signature changed with only a

few victims, so some crimes were not linked to him until he started talking to the child of a victim in 2017.

On December 15, 1977, Richard committed his first murder and eventually became known as the Torso Killer in New York and New Jersey. His method of killing was to beat, rape, and then sodomize the victim. Sometimes he would drug them. He would then pour lighter fluid over the mattresses and his female victims. He also liked to mutilate the bodies. He would remove the head and hands for identification and leave the torso behind.

Interestingly, his name showed up on a list of suspects for the sodomy case of a victim, Diana, who was found after being beaten and sodomized. After hearing a woman's screams, Hasbrouck Heights Motel called the police, and he was arrested May 22, 1980, after trying to escape. He was arrogant enough that he testified at his trial in May of 1981. He was convicted of the murder.

Robert Lee Yates Jr. was born on May 27, 1952, in Oak Harbor, WA. As a child, life was reasonable, and he was athletic. In 1976, he got married and had five children; four daughters and one son. At eighteen years old, he was in the Army as a helicopter pilot and eventually became a pilot for Army National Guard which trained once a month in Tacoma. He did not have a criminal record except for an assault on his daughter on November 12, 1998, but the charge was dropped. Robert had periodic impotence even though he was a regular with the prostitutes. He has been considered an organized serial killer; in control of his actions, and he learned as he continued to kill. He appeared ordinary, and he was well-liked by his peers and family.

Unfortunately, there is not much information about Robert's mental health; however, his killings showed anger and his erectile dysfunction due to psychological problems. Nevertheless, the FBI would consider Robert an organized killer, a lot like Ted Bundy. Interestingly, many

people said that he was well liked and appeared ordinary, so he did not bring much attention to himself. He was also athletic and could hold down a job. Some could say that he was not your typical version of a serial killer. Fascinatingly, numerous times law enforcement passed him over as a suspect because of how he appeared to them.

He was known as the Spokane Serial Killer who abducted and shot prostitutes and drug addicts in the upper body or head. He would wrap a plastic bag around the victim's head, have sex with the dead body, and then dump the bodies in a rural area. Interestingly, the task force had all the information such as a white corvette to arrest Robert since September 25, 1997, but nothing happened. A DMV check did not happen as well even though the police were looking for the car. He was even stopped on a traffic violation on November 10, 1998, with a prostitute in his car, and then again on November 28, 1997; however, he was let go each time. On September 15, 1999, he was interviewed about the November 10, 1998 stop and he said that he was taking the prostitute home per her father's request. During the interview, he sweated profusely, had no alibis, and continued to lie, but he was let go because they did not believe he was guilty. April 10, 2000, there was a search warrant for his previous corvette based on hair fibers. Samples were taken of the car, and there was evidence pointing towards Robert in his car; DNA. He also left DNA on her as well. Overall, the affidavit was all over the place with dates out of sequence and missing dates. The task force failed to catch him because they only relied on DNA and computer technicians. Finally, on April 18, 2000, he was charged with first-degree murder of Jennifer Joseph and he pled guilty on October 19, 2000. He agreed to confess to 13 murders and reveal where some of the bodies were to law enforcement. October 26, 2000, he was sentenced to 408 years with $620,000 in restitution.

Bobby Jo Long was born on October 14, 1953, in Kenova, West Virginia. He was also born with a genetic disorder that caused unusually large breasts in men. His parents divorced in 1955 after continually arguing. His mother took him to Florida to find a better life, but that was a bad idea. It has been said that he tormented animals. His mother eventually remarried a guy named Joe and moved back to Kenova. At age 7, Bobby was hit by a car. He was hit again by a car in 1974 on his motorcycle and was hurt very badly and was discharged from the Army soon after. Also, he married Cynthia in 1974 and divorced in 1980. He had a son and a daughter. He became a Jekyll and Hyde after being hit by a car in 1974. He also became abusive verbally and physically and he derived pleasure from hurting people. He was also self-centered, but he did not drink or smoke. He spoke crudely of girls, and a friend even said that he raped her. He would tell others about watching pornos with teenage girls and them performing the acts. Bobby's IQ has a verbal score of 120, but he did not perform well in school. He was repeatedly an unemployed X-ray technician.

Bobby could be characterized as an ordinary person who after a couple of head traumas, changed profusely; he had post-traumatic stress disorder. He was brilliant like Edmund Kemper. Bobby also had some other mental health problems that could have increased the likelihood that he would eventually become extreme. He repeatedly raped a victim and held her hostage while considering it a relationship at the same time.

He started killing in May 1984, and he became known as the Tampa Bay Killer. His victims were prostitutes, and he strangled them, cut their throat, and sometimes shot them. Interestingly, Bobby was currently on three years of probation for Aggravated Assault in connection to an attempted abduction at gunpoint on April 5, 1984. He raped a girl in Dade County in 1974, but it was pled down to probation. In 1981, Bobby pleaded no contest to sending an obscene letter and

photographs to a 12-year-old girl. He confessed to rapes beginning in 1974 and continued until he was caught by the law. Many doctors said that he had different diagnoses; paraphilia, sexual sadism, or manic-depressive. He was arrested on November 11, 1984, for Lisa McVey's abduction after being questioned about his car. He confessed to the other murders and evidence was found before the trial that began on April 15, 1985, after all the psychological tests. It was a short trial, and the jury took only 45 minutes to reach a guilty verdict with death by electric chair. He received life without parole and the death sentences. He is currently on Death Row in Florida State prison. Interestingly, not all of his victims were murdered. Victim, Lisa McVey was held hostage for 26 hours in Bobby's home, where he repeatedly raped her. He seemed to treat it like a relationship, and then he let her go, so she ran home and called the police.

Richard Ramirez was born on February 29, 1960, in El Paso, Texas. He was the fifth and last child. His parents worked hard, but his father had an explosive temper, and his brother did as well, which got worse over the years. Two of his brothers got into trouble and took drugs. Also, his father's father was a very mean man. Richard quit school at fifteen years old and did drugs, and then he started being a peeping tom. He saw violence when he was a child.

Interestingly, he fell at six years old and was knocked out for several hours. He also witnessed a murder at twelve years old; his cousin killed his wife in front of him. This same cousin showed him some violent sexual acts. Richard had temporal lobe epilepsy. The epilepsy was known to alter his sexuality, and he became excessively aggressive. He was also known to be hyperactive, and Richard was obsessed with feet. He believed he was one with Satan and one with evil. He also thought that the pentagram was necessary, and he was a sadistic killer. Cuts and eviscerations turned him on sexually. Sleeping, eating, and washing did not matter to him, so he had a tawny, strong smell about him. He was also a drug addict.

Richard could be diagnosed with many issues. He did not only have epilepsy, but he had head trauma at six years old; post-traumatic stress disorder. Not to mention that he had grown up in a hostile environment and was addicted to drugs. It could be said that all these issues definitely could have increased his chances that he would kill. More interesting is that he had interesting periods of sanity and only committed minor crimes in-between kills. Unfortunately, there was not any information on his IQ; however, he quit school at fifteen years old, so he had below or average intelligence.

He was known as the Night Stalker and started killing in June 1984 in Los Angeles. He would break and enter homes and stab his victims. In between kills, he would burglarize people's homes for money and stuff to buy cocaine. Sometimes he would even rape, sodomize, and bind his victims. He also restrained his victims with handcuffs or thumb cuffs and then tortured them. He took souvenirs such as eyeballs of a victim, and he either shot, stabbed, or used a machete to kill his victims. He left his shoeprint; 11 ½ size at one crime scene.

Interestingly, he had women followers; they thought he was framed. He was arrested on August 30, 1985, after people in the community recognized him as the Night Stalker by the picture out on him. He was found guilty September 20, 1989, on 46 counts of murder and he is currently in San Quentin on death row.

Richard Trenton Chase was born on May 23, 1950, in Santa Clara County, California. It has been said that he was a victim of abuse by his mother. By age 10, Richard had the MacDonald triad: bedwetting, pyromania, and zoosadism. He had delusions that the Nazi's would turn his blood into power via poison, which was located under his soap dish. He also suffered erectile dysfunction due to psychological problems stemming from repressed anger. He developed hypochondria as he matured to adulthood. He believed his mother was trying to poison him, so

he left home and moved in with his friends. He ended up boarding up his door and creating an escape hatch through his closet wall so no one would sneak up on him.

When his roommates left, he began to capture animals so he could kill them, disembowel them, and would then devour them raw. He thought this prevented his heart from shrinking. In 1975, after injecting rabbit blood into his veins, he was committed to a mental institution. At one point, he escaped but was caught and sent to an institution for the criminally insane, American River Hospital. He drank the blood of birds while there, so the staff called him "Dracula." After psychotropic drugs, he was deemed as not a threat to society, so he was let go in 1976 and sent to his mother who weaned him off the prescribed drugs. Before starting high school, he was popular, well-groomed, and had many friends; however, once Richard reached high school, he became defiant. He started abusing alcohol and drugs and walked around the apartment in the nude, even in front of company. His roommates wanted him to move out, but he would not, so they did. Once alone, things got worse.

At age eighteen, Richard saw a psychiatrist for his impotence, and he was told his suppressed anger from the family issues at home was the cause of his psychological problems. In December 1973, after being admitted to a hospital because he was complaining of chest pains, a psychiatrist believed he suffered from delusions. One doctor felt he had chronic paranoid schizophrenia; however, five months later, he deteriorated rapidly. In June of 1976, he was put in Beverly Manor with a diagnosis of schizophrenia and released in September after appearing well. However, by 1978, he started killing.

He was known as the Vampire of Sacramento or East Side Killer, and he began killing on December 29, 1977. He shot his female victims and had sex with the corpse, mutilated the body, and bathed in the woman's blood. He also drank his victim's blood and was a cannibal.

Interestingly, Richard was arrested after he met up with someone he knew when he was younger at the grocery store. She thought his behavior was off and reported it to the police after the disappearance of David Ferrara. He was arrested on January 28, 1978, the trial started January 2, 1979, on six counts of murder, and he took the stand. On May 8, 1979, after five hours of deliberation, he was found guilty of six counts of murder and was sentenced to die in the gas chamber. Because of his behavior, inmates feared him, and he committed suicide with an overdose of prescribed antidepressants, Sinequan, on December 26, 1980, at San Quentin.

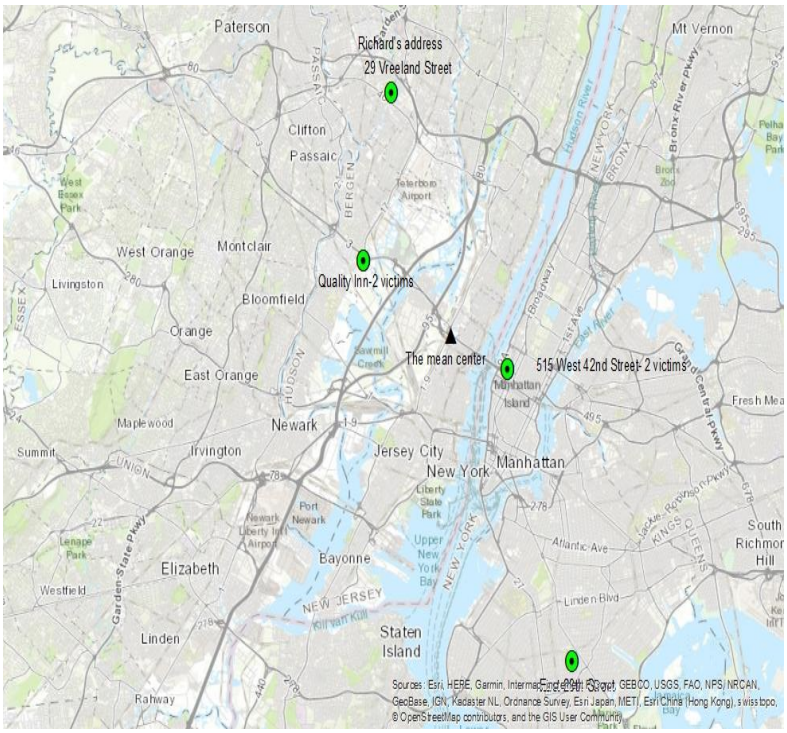
(B) Geographical Profiling Software

The circle hypothesis provides the principle that serial offenders stay within an area of a circle when offending. I hypothesized that serial killers would live and dump their victims within this circle. I did not choose the kill sites because these were not always known to law enforcement. To support this hypothesis, I used the geographical profiling software CrimeStat. I also observed whether mental health or intelligence quotient would have a role in how far a serial killer would travel from his residence.

The five serial killers' documentation of their home location and dumpsite location were inputted into CrimeStat for statistical analysis. The results were saved, which included the X and Y coordinates of the sites, the mean center, standard deviation, and the minimum and maximum distances. The X coordinate represented the longitude while the Y coordinate represented the latitude. These coordinates represented a single location such as a dumpsite of the serial killer's residence. The mean center was the center of all the points on the map. The standard distance deviation is the average distance between the points and the minimum and maximum distances create the boundaries of the points; the two furthest offenses. These results were documented and then put into the ArcMap using the National World Map and base map imagery for the visual

analysis. This analysis ended up showing the serial killer's residence and dumpsites fall with the circle hypothesis, which states that the offender lives within the circle defined by a diameter drawn between that offender's two farthest offenses.

Geographical Analysis of Richard Cottingham's Residence and Dump Sites



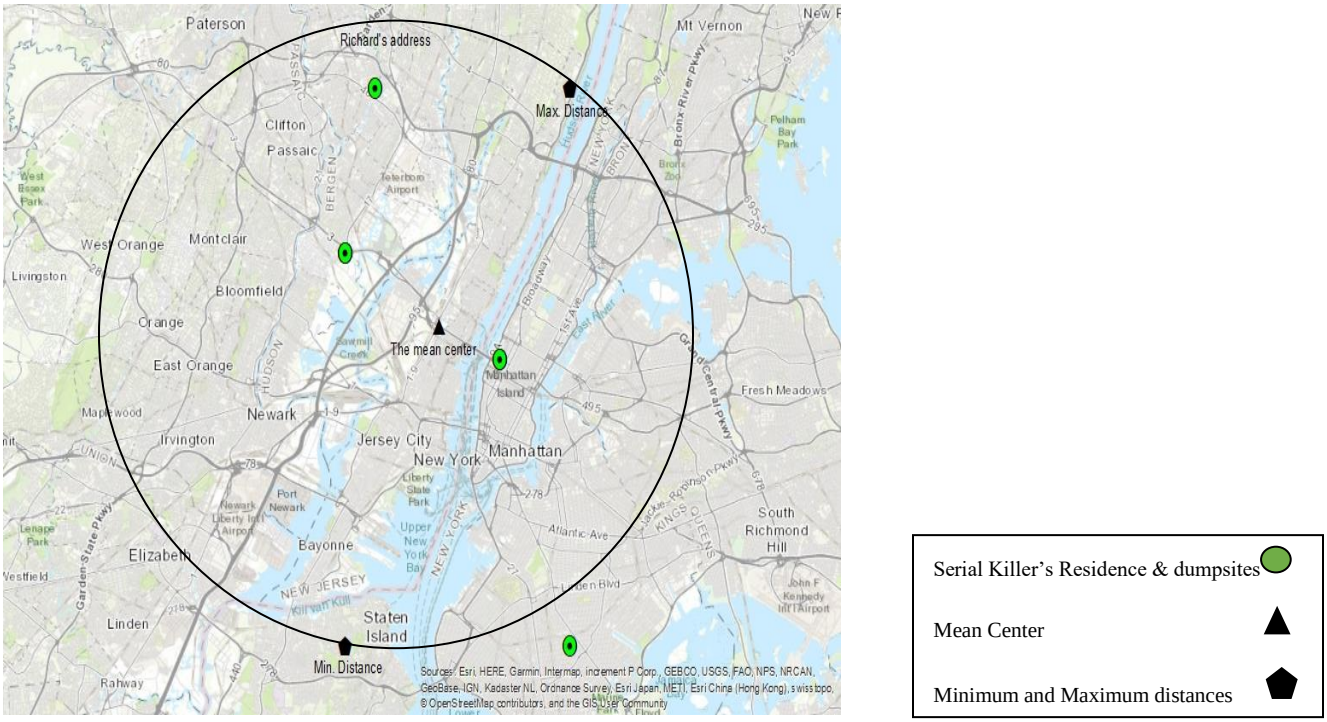
Graph 1 Locations of Richard Cottingham's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

Graph 1 illustrates the different components of this GIS analysis. The first is Richard Cottingham's address. The other points represent three of his dump site locations. Two of the dumpsites had more than one victim dumped there. The triangle signifies the mean center, which is the average between the x and y coordinates. The analysis in Graph 1 has revealed the victim dumpsites had a standard deviation of 7.76 miles from the mean center, which is usually close to the serial offender's residence or anchor point. In this case, the mean center ended up

being eight miles away from Richard Cottingham's residence. Twice, Richard dumped or left bodies in the same place; Quality Inn and at 515 West 42nd Street. He dumped two bodies 3.2 miles from his residence and two other victims 15 miles away from his residence. The final victim ended up being 16 miles away from his residence. When looking at the mean center and the dumpsites, the closest address which was the two victims at the Quality Inn were within two miles of the mean, while the furthest address of East 29th Street was within 11 miles of the mean. Overall, the mean was closer to the dumpsites than Richard's address. Only five victims' dumpsites could be located out of a known total of six victims. Richard claimed to have eighty-five to one hundred victims; however, there is not any evidence that collaborates this claim.

Nevertheless, Richard had a family and could hold down a job, so he possibly had no choice but to stay close to home. He also was brilliant and mentally ill with the paraphilic disorder. The paraphilic disorder which would have kept him close to home may have accounted for the proximity of two dumpsites; 3.2 miles. However, his high intelligence may have accounted for the other victims' dumpsites 15 miles from his residence because he would have been smart enough to put distance between his home and the dumpsites. Overall, Richard's mental illness and IQ did not show conclusively that they played a part in his decisions of where to dump his victims.

Richard Cottingham's Geographical Analysis/Circle Hypothesis

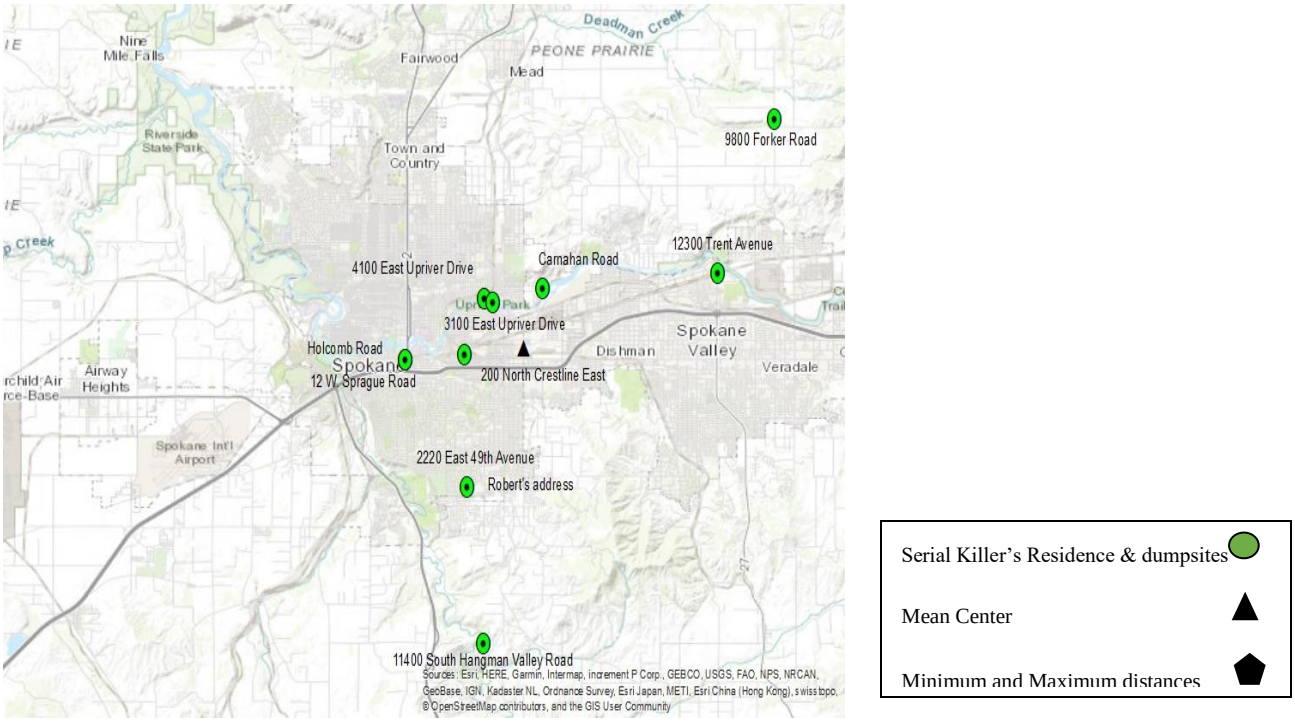


Graph 2 Example of the mean center and center of the minimum and maximum distances.

In Graph 2, the green points represent the serial killer's residence and dumpsites. The triangle signifies the mean center, which is the average between the x and y coordinates. The pentagon represents the calculated minimum and maximum distances. The pentagon signifies the minimum and maximum distances, which would be the two farthest points of the circle on the map.

The analysis in Graph 2 has shown that the distance from the mean to the minimum distance and the maximum distance covers all of the dumpsites and Richard's address. Richard lived within seven miles of the maximum distance and 18 miles of the minimum distance. The circle that was drawn to define the area from the minimum and maximum distances, clearly shows a circle encompassing the sites and it supports the circle hypothesis.

Geographical Analysis of Robert Lee Yate's Residence and Dump Sites



Graph 3 Locations of Robert Lee Yate's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

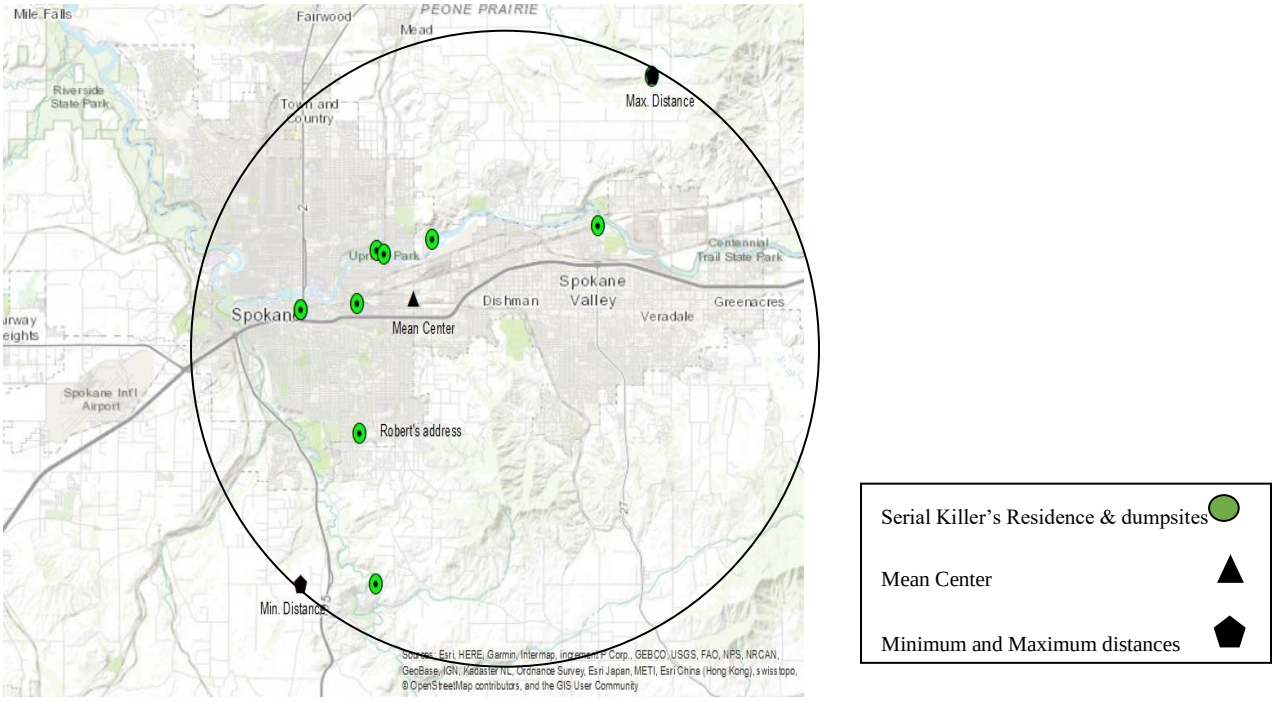
Graph 3 illustrates the different components of this GIS analysis. The first is Robert Lee Yate's address. The other points represent three of his dump site locations. The triangle signifies the mean center which is the average between the x and y coordinates. The analysis in Graph 3 has revealed that with only a sample set of nine victims' out of a known total of eighteen victims, the standard distance deviation was only 5.10 miles from the mean center. In this case, the mean center was closer to Robert Yate's residence; 3.8 miles.

Many of the dumpsites were clustered together in one area; which was very close to the mean center. Twice, Robert dumped or left bodies in the same area; once on East Upriver Drive and another time where Holcomb and Sprague Road. On at least two separate occasions, Robert dumped victims at least 11 miles away from his residence. When looking at the mean center and

the dumpsites, six of the dumpsites were under five miles from the mean, while three dumpsites were over five miles from the mean. Overall, the mean was closer to the dumpsites than Robert's address.

Nevertheless, Robert had a family and could hold down a job, so he possibly had no choice but to stay close to home. Also, it appears that he was more interested in hurting prostitutes because of his mental illness; erectile dysfunction disorder. Since there was not any information on his intelligence, it can be assumed that it was in the normal range. The erectile dysfunction disorder which would have him hunt for easy victims may have accounted for the dumpsites being clustered together and close to areas frequented by prostitutes. His average intelligence may have accounted for the clustered dumpsites as well. Overall, Robert's mental illness and IQ did not show conclusively that they played a part in his decisions of where to dump his victims.

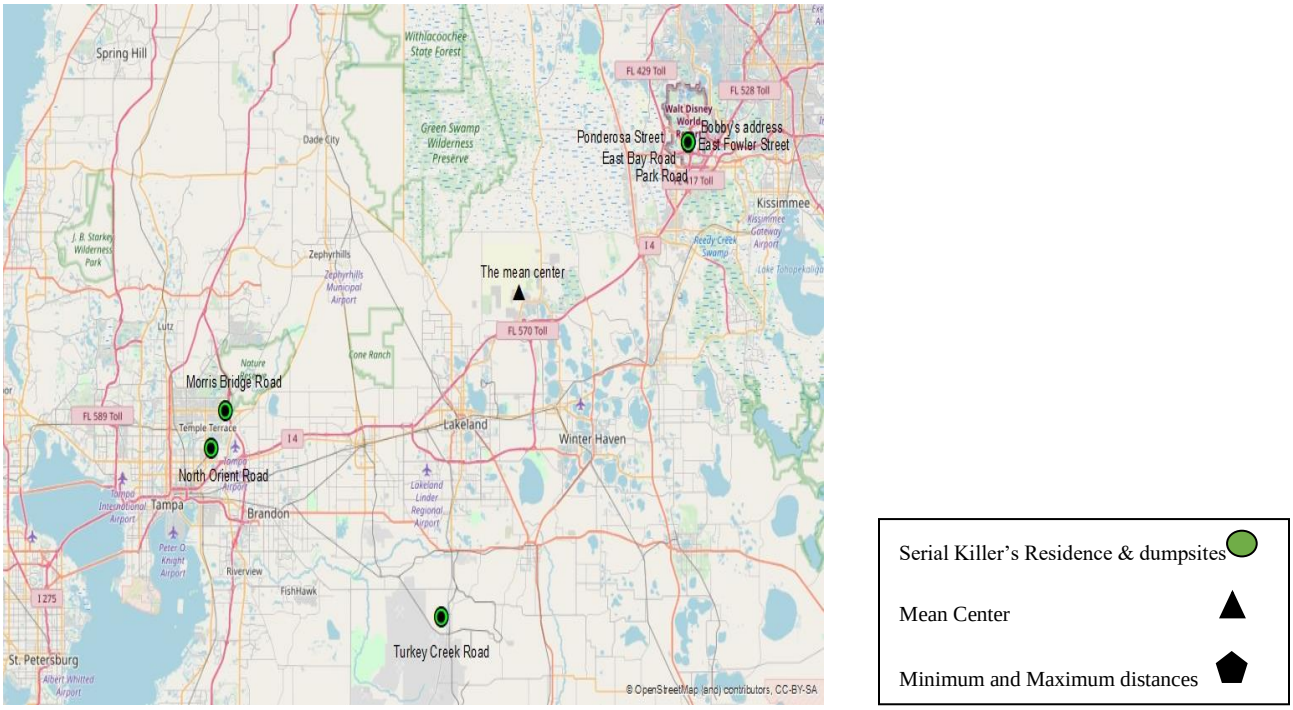
Robert Lee Yate's Geographical Analysis/Circle Hypothesis



Graph 4 Example of the mean center and the minimum and maximum distances.

In Graph 4, the pentagon represents the calculated minimum and maximum distance. The pentagon signifies the minimum and maximum distances, which would be the two farthest points of the circle on the map. The analysis in Graph 4 has shown that the distance from the mean to the minimum distance is and the maximum distance cover all of the dumpsites and Robert's address. One interesting fact is that the maximum distance overlaid Robert's address. The circle that was drawn to define the area from the minimum and maximum distances, clearly shows a circle encompassing the sites and it supports the circle hypothesis.

Geographical Analysis of Bobby Jo Long's Residence and Dump Sites



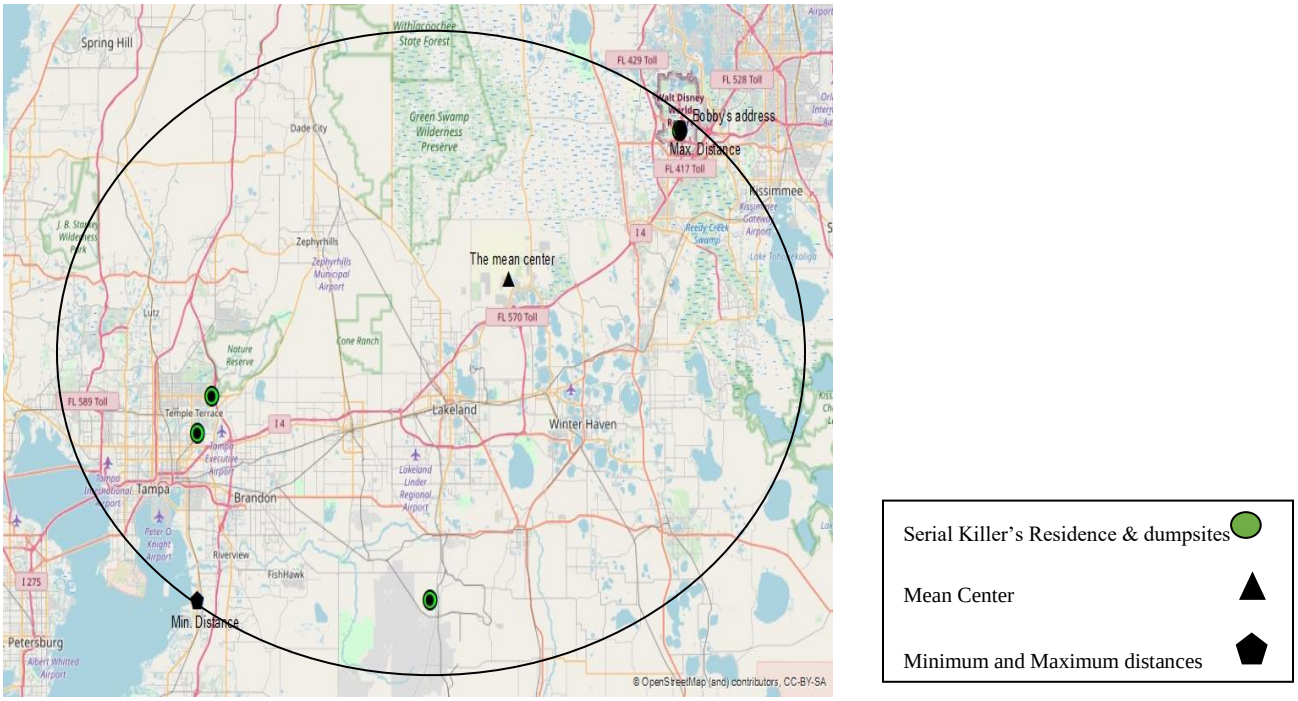
Graph 5 Locations of Bobby Jo Long's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

Graph 5 illustrates the different components of this GIS analysis. The first represents Bobby Jo Long's address, along with four dumpsites. Bobby Jo Long's address and four dumpsites

were located incredibly close, if not on top of the maximum distance coordinate. The triangle signifies the mean center, which is the average between the x and y coordinates. The analysis in Graph 5 has revealed that with only a sample set of six victims' out of a known total of ten victims, the standard distance deviation was 30 miles from the mean center which is the second furthest of the five serial offenders. Also, the mean center was also 21 miles from Bobby Jo Long's residence. When looking at the mean center and the dumpsites, the mean was far from Bobby's address as well as three addresses. Even though the mean was not close to Bobby's address, 21 miles away, the mean was also at a distance from the dumpsites. The closest dumpsite was 21 miles from the mean, while the furthest was 34 miles from the mean.

The strangest thing is that Bobby Jo had three dumpsites close to home; however, he also ventured further out on three separate occasions. On one occasion, he traveled 22 miles from his residence. Nevertheless, Bobby Jo was brilliant and mentally ill with post-traumatic stress disorder and paraphilic disorder. The post-traumatic stress disorder and paraphilic disorder, which would have kept him close to home may have accounted for the proximity of four dumpsites. However, his high intelligence may have accounted for the other victims' dumpsites 21 miles from his residence because he would have been smart enough to put distance between his home and the dumpsites. Evaluation of Bobby's mental illness and IQ did not show conclusively that they played a part in his decisions of where to dump his victims.

Bobby Jo Long's Geographical Analysis/Circle Hypothesis



Graph 6 Example of the mean center and the center of the minimum and maximum distances.

In Graph 6, the pentagon represents the calculated minimum and maximum distance. The pentagon signifies the minimum and maximum distances, which would be the two farthest points of the circle on the map. The analysis in Graph 6 has shown that the distance from the mean to the minimum distance is and the maximum distance cover all of the dumpsites and Bobby's address. One interesting fact is that Bobby's address is overlaid with the maximum distance. The circle that was drawn to define the area from the minimum and maximum distances, clearly shows a circle encompassing the sites and it supports the circle hypothesis.

Geographical Analysis of Richard Ramirez's Residence and Dump Sites

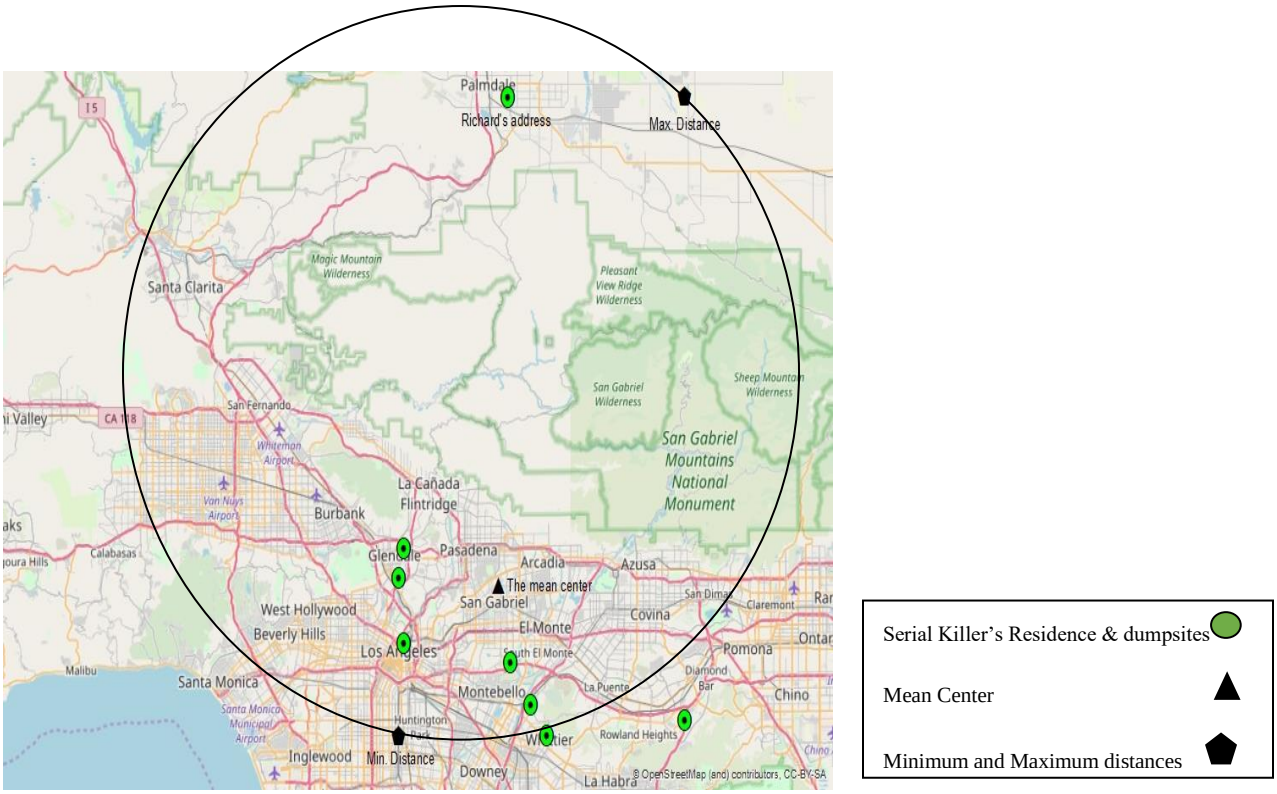
Graph 7 Locations of Richard Ramirez's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

Graph 7 illustrates the different components of this GIS analysis. The first represents Richard Ramirez's address along with seven dumpsites. The triangle signifies the mean center, which is the average between the x and y coordinates. The analysis of Graph 7 has revealed that with only a sample set of seven victims' out of a known total of fourteen victims, the standard distance deviation was 16.7 miles from the mean center. Also, the mean center was also 31 miles from Richard Ramirez' residence. When looking at the mean center and the dumpsites, the mean is closer to the dumpsites than Richard's address. Six were within ten miles of the mean, while only one dumpsite was over ten miles.

The map shows that Richard lived the furthest from the mean center and his dumpsites. Nevertheless, Richard dropped out of school, which means he either had low or average intelligence; however, he was mentally ill with multiple disorders. He had epilepsy, addiction to

drugs, post-traumatic stress disorder, and paraphilic disorder. Interestingly, epilepsy made him extremely aggressive. Richard also was addicted to drugs and believed he was Satan. All of these disorders may have accounted for the proximity of the scattered dumpsites. Evaluation of Richard's mental illness and IQ did not illustrate conclusively that they played a part in his decisions of where to dump his victims.

Richard Ramirez's Geographical Analysis/Circle Hypothesis

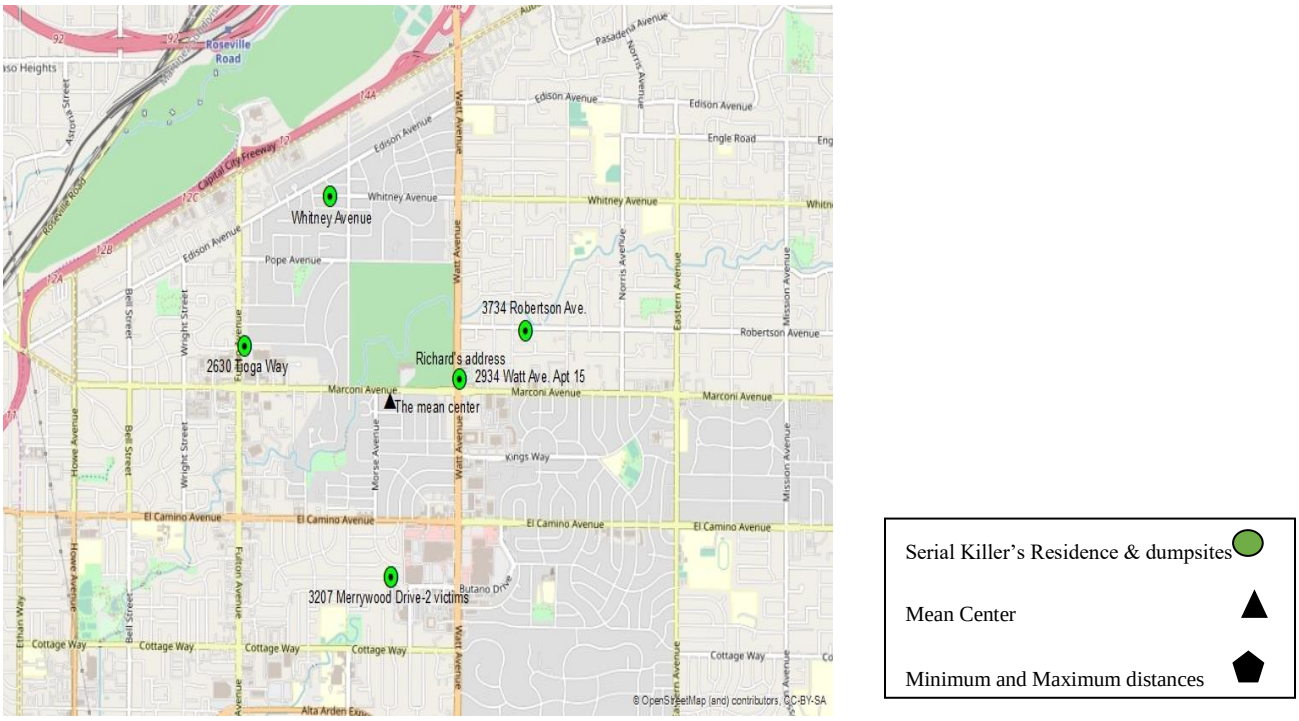


Graph 8 Example of the mean center and the center of the minimum and maximum distances.

In Graph 8, the pentagon represents the calculated minimum and maximum distances. The pentagon signifies the minimum and maximum distances, which would be the two farthest points of the circle on the map. The analysis in Graph 8 has shown that the distance from the mean to the minimum distance is and the maximum distance cover all the dumpsites and Richard's

address. Richard lives with 14 miles of the maximum distance; the closest point to his address. The circle that was drawn to define the area from the minimum and maximum distances, clearly shows a circle encompassing the sites and it supports the circle hypothesis.

Geographical Analysis of Richard Chase's Residence and Dump Sites



Graph 9 Locations of Richard Chase's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

Graph 9 illustrates the different components of this GIS analysis. The first represents Richard Chase's address. The other points represent four of his dump site locations. The triangle signifies the mean center, which is the average between the x and y coordinates. The analysis in Graph 9 has revealed that Richard Chase lived the closest to the mean center at 0.33 miles and his dumpsites with a standard deviation of 0.81 miles. One victim was dumped under

a mile from his residence. The circle area was defined by two square miles, the lowest of the five serial killers.

When looking at the mean center and the dumpsites, the mean and Richard's address were close to the dumpsites. Three of the dumpsites were under 0.69 miles from the mean, while only two were over 0.7 miles from the mean. Either way, Richard stayed close to the dumpsites.

Nevertheless, there was not any information on Richard's IQ, so he either had low or average intelligence. However, he was mentally ill with multiple disorders. He had erectile dysfunction disorder, addiction to alcohol and drugs, Macdonald triad, and schizophrenia. Some doctors believed he was delusional and paranoid schizophrenic. All these disorders may have accounted for the proximity of his home and dumpsites. Overall, Richard's mental illness and IQ did not show conclusively that they played a part in his decisions of where to dump his victims.

Richard Chase's Geographical Analysis/Circle Hypothesis

Graph 10 Example of the mean center and the center of the minimum and maximum distances.

In Graph 10, the pentagon represents the calculated minimum and maximum distance. The pentagon signifies the minimum and maximum distances, which would be the two farthest points of the circle on the map. The analysis in Graph 10 has shown that the distance from the mean to the minimum distance is and the maximum distance cover all of the dumpsites and Richard's address. Richard lived the closest to the mean center. The circle that was drawn to define the area from the minimum and maximum distances, clearly shows a circle encompassing the sites, and it supports the circle hypothesis.

VI. DISCUSSION

The purpose of this research is to determine whether geographic profiling software programs can assist in serial murder cases. This study utilized geographical profiling software to look at the significance of disposal or dump sites, the residence of the killer, and the distance between the dumpsite and the serial killer's residence. This study also examined the extent to which mental health and intelligence may mediate an offender's decision regarding the location of the dump site locations. The study utilized a mixed methods approach with case studies and geographical information system analysis to address these aims.

The findings supported the circle hypothesis in that serial killers do stay within their home or comfort zone like the study done by Cantor, Coffey, Huntley, and Missen in 2000. That study showed that 79 serial killer's residences were located within the area of a circle. 100% of this sample criteria supported the circle hypothesis; each serial killer dumped within the circle as well as resided there. In the same year, Gacono (2000) asserted that there is a connection between psychopathy and violent crime. However, this study did not support the idea that mental health or intelligence quotient affected the results conclusively of where a serial killer dumps his

victims. It was difficult to illustrate that mental illness and IQ impacted the serial killer's choice of dumpsite decision.

Observing all five serial killers, some similarities and exciting facts came to light. For example, three serial killers traveled under ten miles to their dumpsites, while two serial killers traveled between twenty and thirty miles. Both Richard Cottingham and Bobby Jo Long had high IQs, and they stayed close to home for a few dumpsites and traveled a distance for other dumpsites. For example, Bobby Jo Long dumped three victims close to his residence, but he also traveled up to twenty-two miles to one dumpsite location. Therefore, intelligence quotient could have impacted where they would dump the victims. Bobby Jo Long also traveled the farthest to dump a body; twenty-two miles. When observing the two that traveled further, a key component was that they lived in a small area in a bigger metropolitan city; Los Angeles and Tampa Bay area. Richard Chase stayed the closest to home with one dumpsite at .6 miles from his residence. His mental issues such as paranoid schizophrenic, hypochondriac, and delusions could explain the distance he traveled to kill his victims.

Overall, the present study produced one significant finding; the application of geographical profiling software can aid in the investigation of serial murder. With the use of content analysis and case studies, this study yielded that the circle hypothesis works. It also showed that the mental health and IQ of a serial killer are not necessarily significant in their travel from their residence. In general, the findings did not prove or disprove that mental health or IQ had a lot to do with distance a serial killer would travel to dump a body. Thus, the findings from the research support the idea that serial killers stay within their comfort zone, which consists of their residence. It also supports the idea that the dumpsites are relative to the residence. The serial

killer's residences were found within the circle when you added the minimum and maximum distances to the map for each serial killer.

Today, serial killers have yet to be studied to the extent that they should be in order to compare my results to multiple studies. Like the study performed by Cantor, Coffey, Huntley, and Missen in 2000, this study also showed that the five serial killers stayed within the search area of the circle. In contrast to most of the previous studies that focused on the geographic software system and serial killers, this study also evaluated whether IQ or mental illness played a part in the distance a serial killer would travel to dump the victims.

Social Policy Implications

In 1990, the Vancouver Police Department established the world's first geographic profiling. In a study performed by Roth, Ross, Finch, Luo, and MacEachren, they discovered that some agencies occasionally use geographic software for the mean calculation; however, they focus more on maps from Google or ArcGIS (Roth, Ross, Finch, Luo, & MacEachren, 2013). However, these police stations do not use it to apprehend serial criminals but for jobs such as mapping crime and finding hot spots for high crime activity (2000).

Geographical information systems have slowly been incorporated into law enforcement agencies, starting with larger cities with more significant populations in the United States (Fernandino, 2015) such as the New York Police Department in the United States and the Vancouver Police Department in Canada (Rossmo, 2000). It has also been used outside of the United States. Cooper, Schmitz, Capt. Byleveld, and Dr. Rossmo found that using the maps aided a court case on the Wemmerpan Serial Killer in South Africa. Currently, they are using the same idea on the Nasrec serial killer case (Cooper, Schmitz, Byleveld, Rossmo, 2018).

Medeiros stated that geographic profiling is used regularly in the United Kingdom in high profile cases (Miller, 2014).

A proposed course of action would be a hybrid approach; geographical profiling software and DNA findings incorporated into the investigations for all law enforcement agencies. This approach includes local agencies as well as other agencies such as the FBI, Homeland Security, and the CIA. Past studies in places like England and Canada, has shown that the geographical software has helped investigations in serial crimes. More, recently, the FBI has shown that it is possible to catch serial offenders through acquired DNA samples. Nevertheless, this hybrid approach would be useful in all serial crimes to give a better view of the evidence as well as the possibility of seizing a serial offender.

The results from this study and past research suggest that geographic profiling aids in the capture of serial killers. It showed that five serial killers stayed relatively close to their residence or their comfort zone. It also showed that they stayed within the search area of the circle, supporting the circle hypothesis. Therefore, if it works on serial killers, then it should be productive on other serial crimes such as burglary and rape. Nevertheless, it is necessary and should become a policy for law enforcement to use software like CrimeStat in apprehending a serial killer or any serial offender.

VII. CONCLUSION

Overall, this study examined the validity of the circle hypothesis to prove that geographical profiling can assist law enforcement by looking at the significance of disposal or dump sites, the residence of the killer, and the distance between the dumpsite and the serial killer's residence. These were essential clues because most people stay within their comfort zone. So, if an individual generally stays within a specific area, it is very likely that a serial killer will also stay

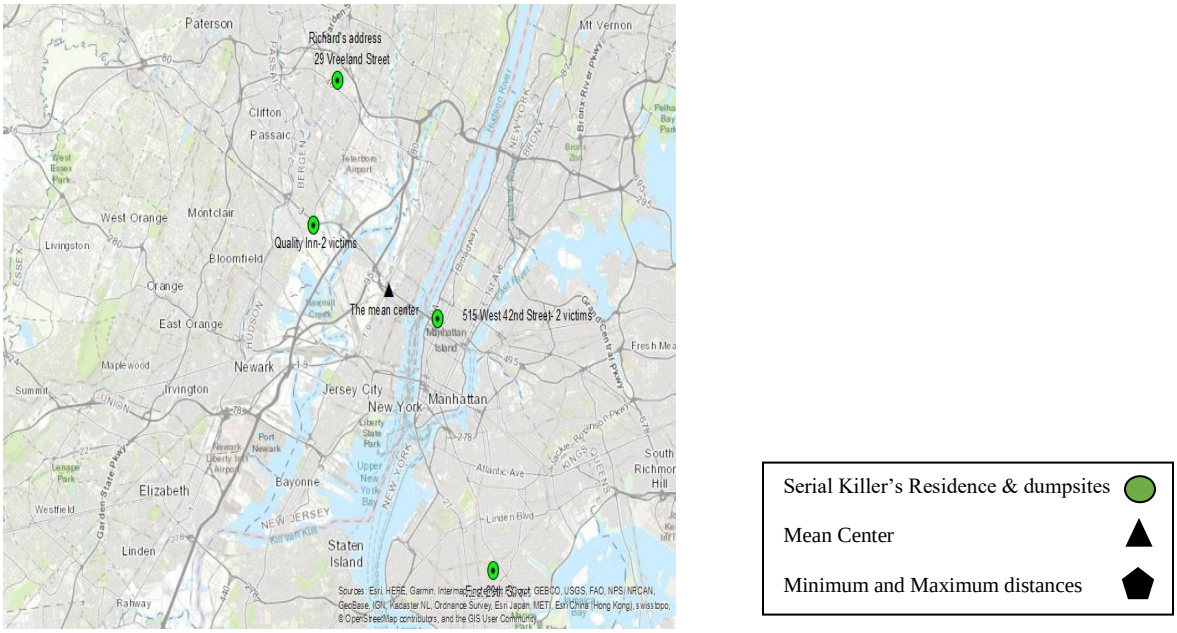
in his/her comfort zone and commit crimes. The results confirmed that geographical profiling could be a tool in serial murder investigations.

Some limitations to this study were the sample size and the geographical location of these serial killers. Perhaps if the sample size were bigger such as 20 serial killers, the results would not support the circle hypothesis. Also, these five serial killers lived in metropolitan areas. Perhaps if the serial killers lived in cities in the Midwest, the results would show all dumpsites clustered together. Nevertheless, I would recommend a bigger sample size and at least five serial killers from midwestern cities to see if the outcome is the same, and it supports the circle hypothesis.

Nevertheless, the findings supported the idea that serial killers do stay within their home or comfort zone when they kill as others stay within their comfort zone or home to shop, eat, and get gas. It is important to remember that humans tend to develop habits and tend to stay close to home or a place they consider home or at the very least, a comfort zone. Bowers, Johnson, Guerette, Summers, and Poynton (2011) felt that how far an offender will travel is vital in prevention. Therefore, the movement of offenders is critical these days. Furthermore, if a system can figure out those habits and develop an answer, then this software system can make inroads into other issues such as preventing terrorist attacks. Therefore, the next phase is to apply geographical profiling to other serial crimes such as burglary and rape. I suggest a hybrid approach to a serial crime that would assist law enforcement agencies in their endeavor to apprehend the criminal quickly and efficiently by using geographical profiling and DNA findings.

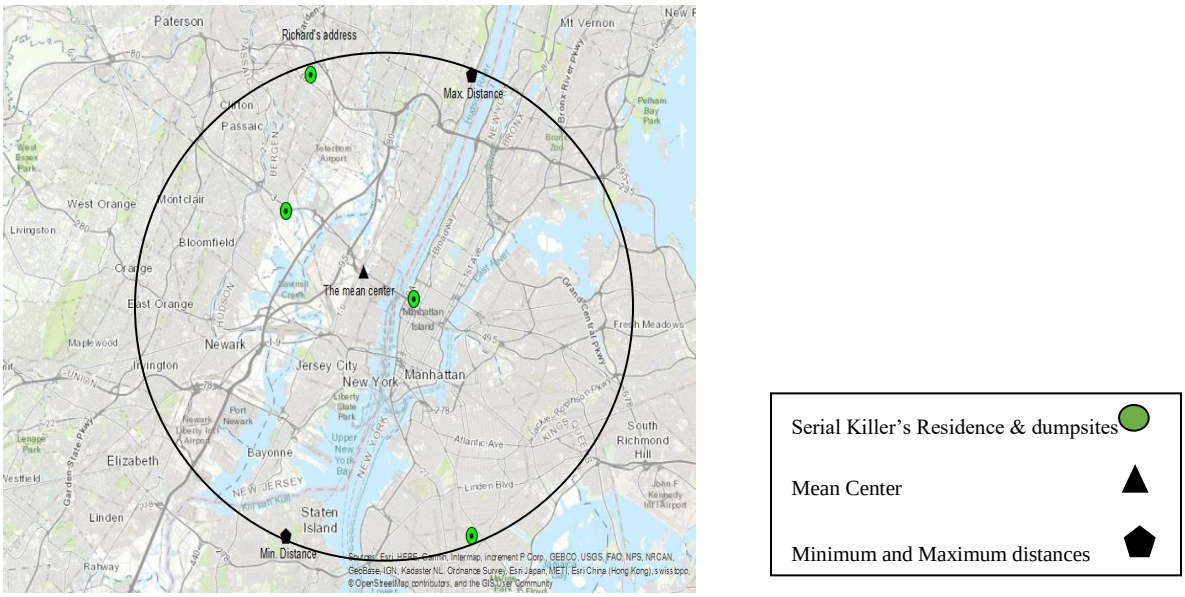
VIII. APPENDIX

Geographical Analysis of Richard Cottingham's Residence and Dump Sites



Graph 11 Locations of Richard Cottingham's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

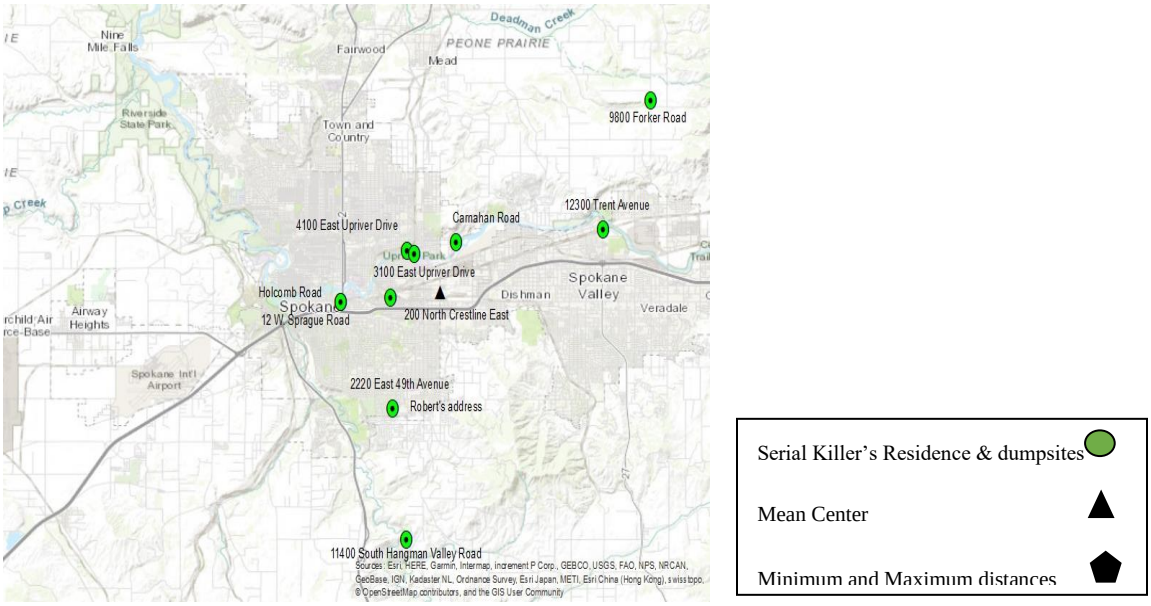
Richard Cottingham's Geographical Analysis/Circle Hypothesis



Graph 12 Example of the mean center and center of the minimum and maximum distances.

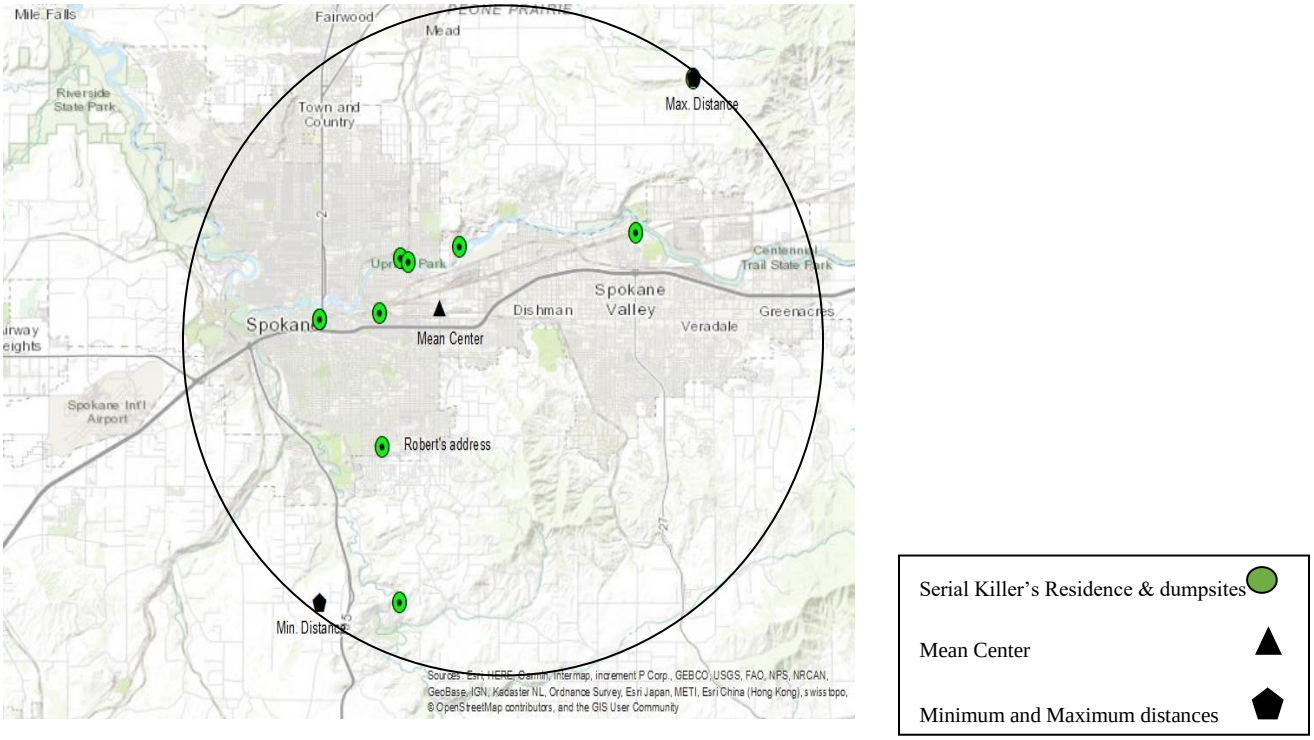
```
Mean Center and Standard Distance Deviation:
-------------------------------------------

    Sample size ...........:  6
    Measurement type ......:  Direct
    Start time ............:  04:10:24 PM, 01/27/2019
    Unit ..................:  Degrees

    Variable ..............:              X            Y
    Minimum ...............:    -74.103540    40.625480
    Maximum ...............:    -73.947650    40.887000
    Mean ..................:    -74.038222    40.775303
    Standard Deviation ....:      0.066797     0.086904
    Geometric Mean ........:    -74.038197    40.775226
    Harmonic Mean .........:    -74.038171    40.775149

    Average Density .......:      0.000000 points per sq. m

    Std Dist. Dev .........:  12494.65 m, 40992.95 ft, 7.76382 mi

    Circle Area Defined
    by Std Dist. Dev .....:  490453905.34 sq. m
                            5279201900.62 sq. ft.
                            189.36531 sq. mi
```

Geographical Analysis of Robert Lee Yate's Residence and Dump Sites



Graph 13 Locations of Robert Lee Yate's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

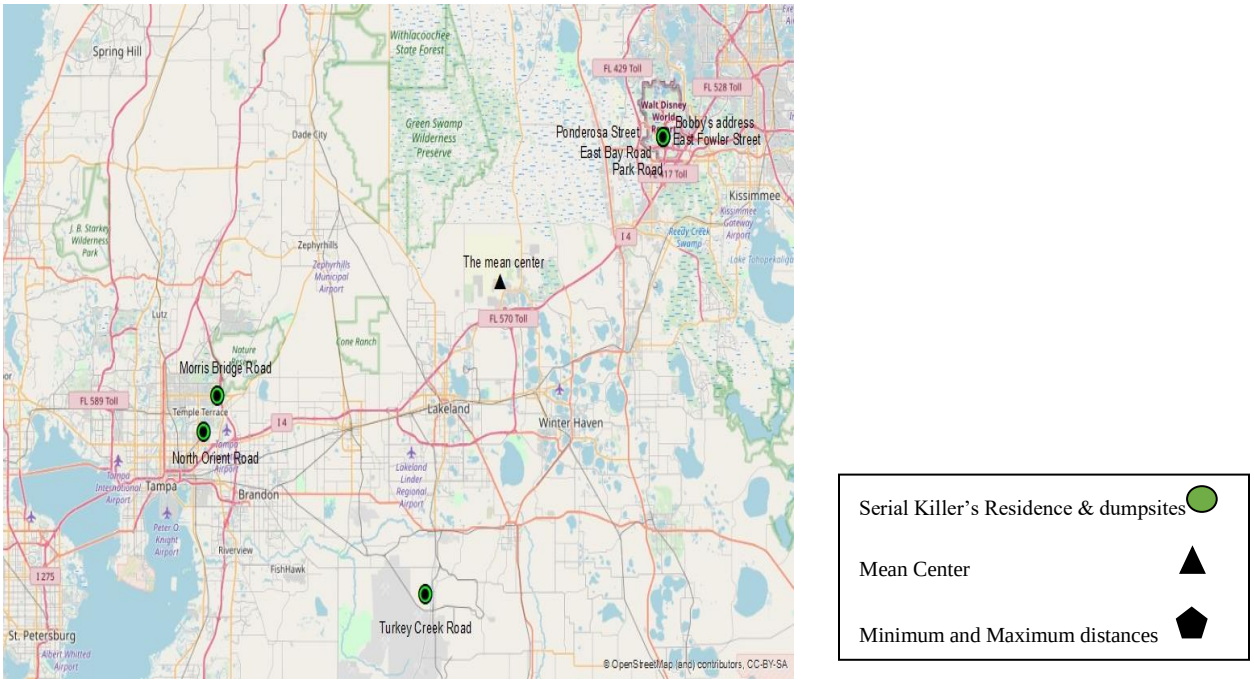
Robert Lee Yate's Geographical Analysis/Circle Hypothesis



Graph 14 Example of the mean center and the minimum and maximum distances.

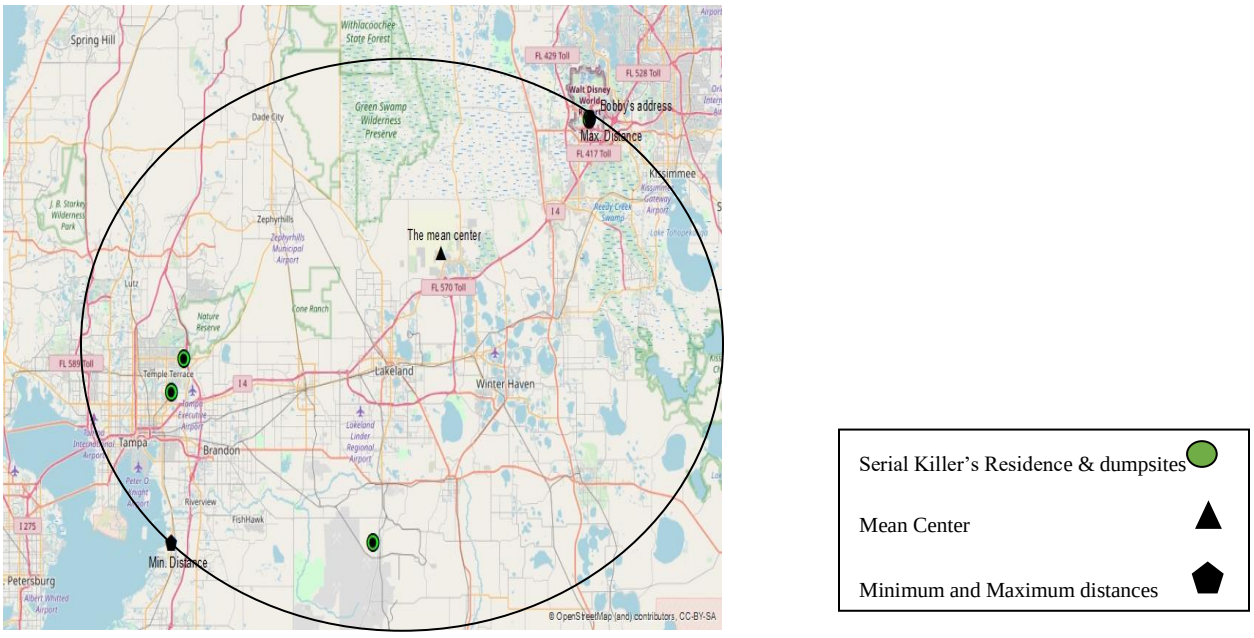
```
Mean Center and Standard Distance Deviation:
--------------------------------------------

    Sample size ...........:  11
    Measurement type ......:  Direct
    Start time ............:  04:18:22 PM, 01/27/2019
    Unit ..................:  Degrees

    Variable ..............:              X            Y
    Minimum ...............:   -122.458360    47.158990
    Maximum ...............:   -117.207520    47.747310
    Mean ..................:   -117.811271    47.615786
    Standard Deviation ....:      1.542658     0.159285
    Geometric Mean ........:   -117.802300    47.615543
    Harmonic Mean .........:   -117.793535    47.615298

    Average Density .......:      0.000000 points per sq. m

    Std Dist. Dev .........:  123692.80 m, 405816.27 ft, 76.85914 mi

    Circle Area Defined
    by Std Dist. Dev .....:  48066081430.18 sq. m
                            517378994596.73 sq. ft.
                            18558.41779 sq. mi
```

Geographical Analysis of Bobby Jo Long's Residence and Dump Sites



Graph 15 Locations of Bobby Jo Long's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

Bobby Jo Long's Geographical Analysis/Circle Hypothesis

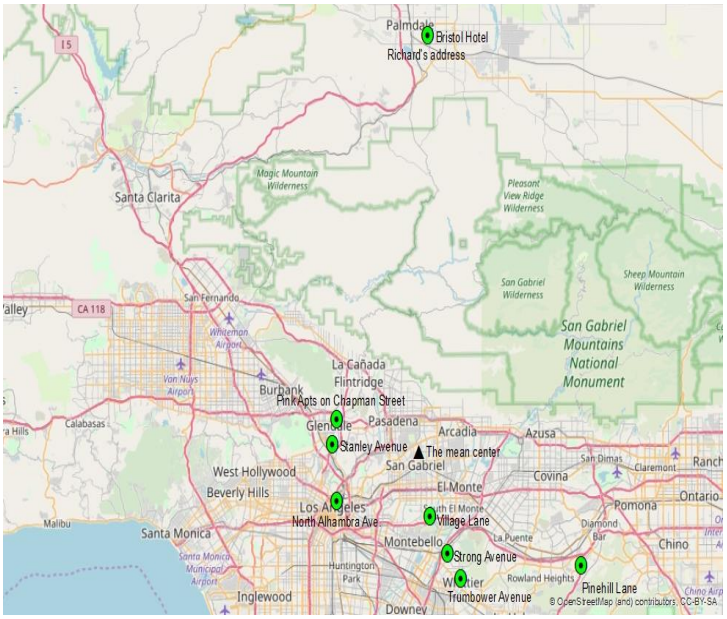


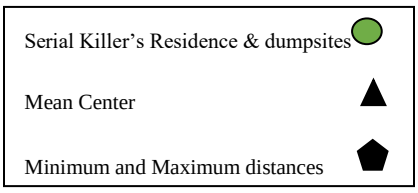
Graph 16 Example of the mean center and the center of the minimum and maximum distances.

Mean Center and Standard Distance Deviation:

```
-------------------------------------------

    Sample size ..........:  7
    Measurement type .....:  Direct
    Start time ...........:  03:38:59 PM, 01/27/2019
    Unit .................:  Degrees

    Variable .............:             X            Y
    Minimum ..............:    -82.383150    27.820070
    Maximum ..............:    -81.568980    28.362810
    Mean .................:    -81.858490    28.191207
    Standard Deviation ....:      0.382713     0.225880
    Geometric Mean .......:    -81.857724    28.190429
    Harmonic Mean ........:    -81.856960    28.189649

    Average Density .......:      0.000000 points per sq. m

    Std Dist. Dev ..........:  49427.23 m, 162162.84 ft, 30.71266 mi

    Circle Area Defined
    by Std Dist. Dev .......:  7675072303.25 sq. m
                              82613790713.96 sq. ft.
                              2963.36198 sq. mi
```

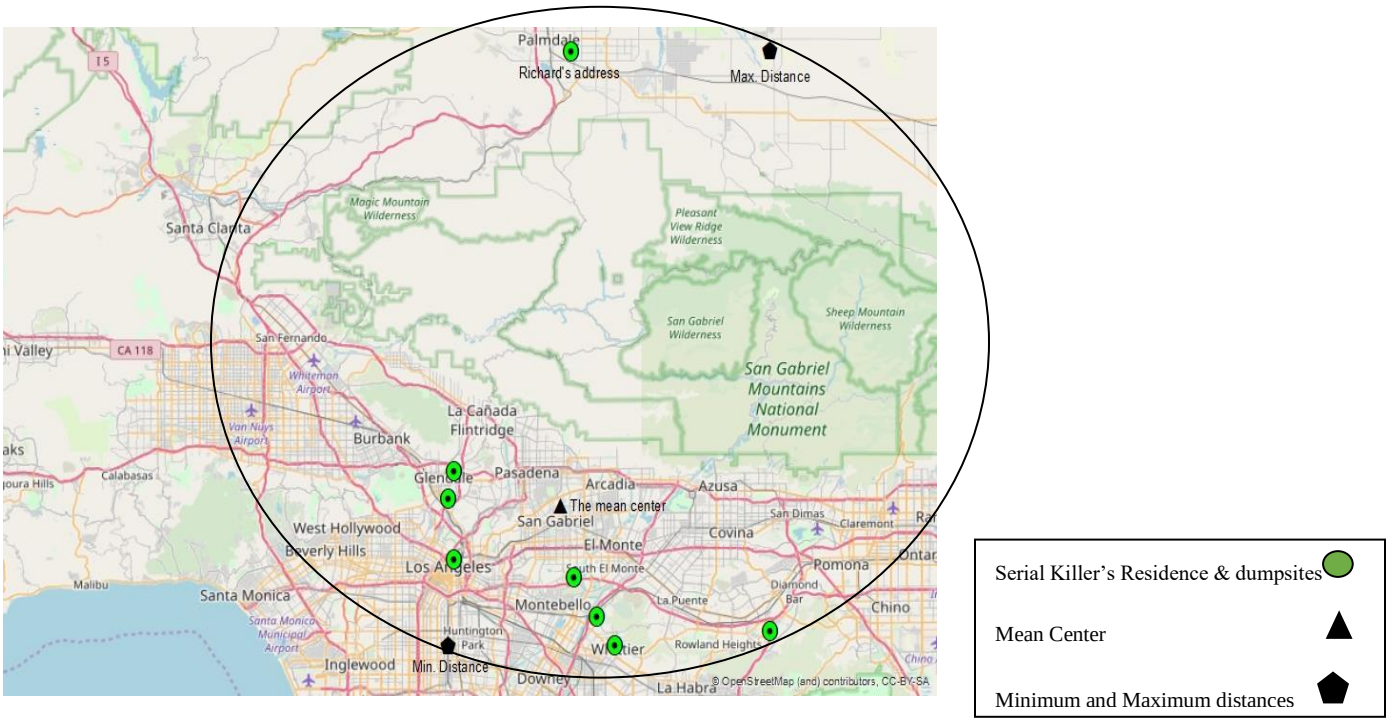
Geographical Analysis of Richard Ramirez's Residence and Dump Sites





Graph 17 Locations of Richard Ramirez's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

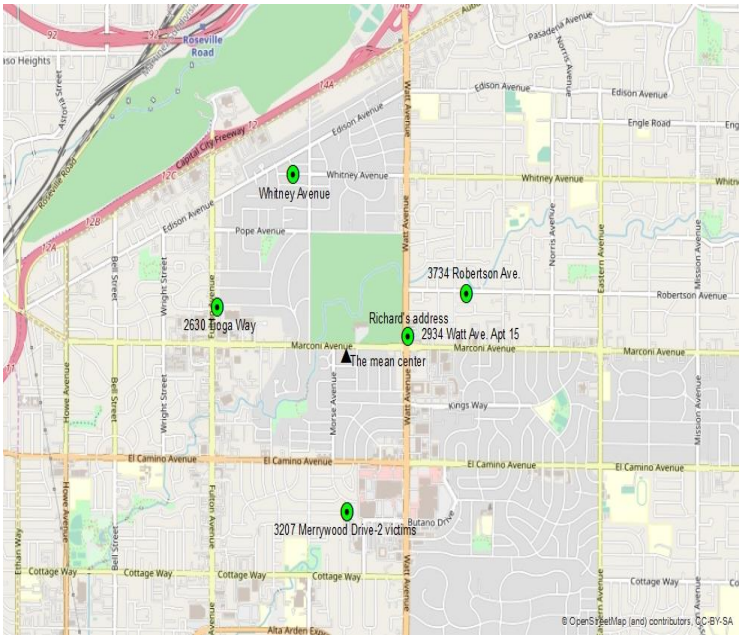
Richard Ramirez's Geographical Analysis/Circle Hypothesis



Graph 18 Example of the mean center and the center of the minimum and maximum distances.

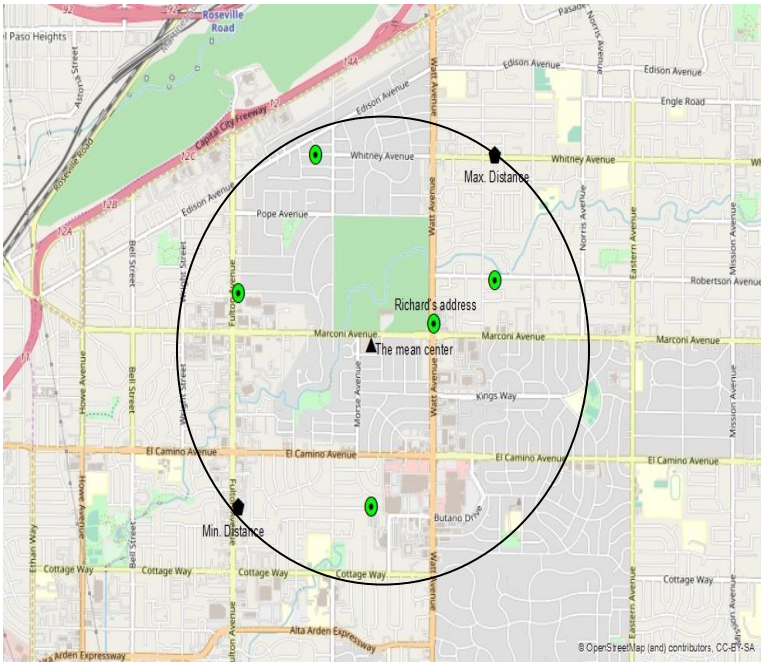
```
Mean Center and Standard Distance Deviation:
--------------------------------------------

    Sample size ...........:  8
    Measurement type ......:  Direct
    Start time ............:  04:14:49 PM, 01/27/2019
    Unit ..................:  Degrees

    Variable ..............:              X             Y
    Minimum ...............:   -118.242920    33.975420
    Maximum ...............:   -117.839810    34.568530
    Mean ..................:   -118.102335    34.114093
    Standard Deviation ....:      0.137013     0.193642
    Geometric Mean ........:   -118.102265    34.113615
    Harmonic Mean .........:   -118.102196    34.113140

    Average Density .......:      0.000000 points per sq. m

    Stud Dist. Dev ........:  26941.90 m, 88392.06 ft, 16.74092 mi

    Circle Area Defined
    by Stud Dist. Dev .....:  2280375160.37 sq. m
                             24545753942.68 sq. ft.
                             880.45777 sq. mi
```

Geographical Analysis of Richard Chase's Residence and Dump Sites



Graph 19 Locations of Richard Chase's residence (green dot), the mean center (black triangle), and victim dumpsites (green dots). The residence and dumpsites include the address.

Richard Chase's Geographical Analysis/Circle Hypothesis



Graph 20 Example of the mean center and the center of the minimum and maximum distances.

Mean Center and Standard Distance Deviation:

Sample size	6
Measurement type	Direct
Start time	04:05:15 PM, 01/27/2019
Unit	Degrees

Variable	X	Y
Minimum	-121.400920	38.607390
Maximum	-121.377240	38.628790
Mean	-121.388658	38.617282
Standard Deviation	0.008253	0.008423
Geometric Mean	-121.388658	38.617281
Harmonic Mean	-121.388658	38.617280

Average Density ..... : 0.000000 points per sq. m

Stud Dist. Dev ..... : 1318.05 m, 4324.30 ft, 0.81900 mi

Circle Area Defined
by Stud Dist. Dev ..... : 5457725.91 sq. m
58746472.79 sq. ft.
2.10724 sq. mi

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